Service

Marine Generator Sets

Models:

40COZ/33CFOZ, 40EOZ/33EFOZ
50COZ/40CFOZ, 50EOZ/40EFOZ
65COZ/50CFOZ, 65EOZ/55EFOZ
80EOZ/70EFOZ, 99EOZ/80EFOZ
125EOZ/100EFOZ, 150EOZ/125EFOZ

Controllers:
Decision-Maker™ 3+
Decision-Maker™ 1 Standard
Decision-Maker™ 1 Expanded

ISO 9001
KOHLER GENERATORS
INTERNATIONALLY REGISTERED

KOHLER®
POWER SYSTEMS

TP-5737 5/01b

Product Identification Information

Product identification numbers determine service parts. Record the product identification numbers in the spaces below immediately after unpacking the products so that the numbers are readily available for future reference. Record field-installed kit numbers after installing the kits.

Generator Set Identification Numbers

Record the product identification numbers from the generator set nameplate(s).

Model Designation _____

Specification Number _____

Serial Number _____

Accessory Number	Accessory Description

Engine Identification

Record the product identification information from the engine nameplate.

Manufacturer _____

Model Designation _____

Serial Number _____

Table of Contents

Product Identification Information ..... **Inside front cover**

Safety Precautions and Instructions ..... **i**

Introduction ..... **i**

Service Assistance ..... **i**

Section 1 Specifications **1**

1.1 Introduction 1
1.2 Specifications 1
1.3 Accessories 2
1.3.1 Remote Annunciator Kit 2
1.3.2 Safeguard Breaker 3
1.3.3 Line Circuit Breaker 3
1.3.4 Run Relay Kit 3
1.3.5 FASTCHECK Diagnostic Tester (Microprocessor Controller Only) 4

Section 2 Operation **5**

2.1 Fast-Response™ II Concepts 5
2.2 Short Circuit Performance 5
2.3 Prestart Checklist 6
2.4 Marine Inspection 6
2.5 Angular Operation 6
2.6 Exercising the Generator Set 6
2.7 Decision-Maker™ 3+ 16-Light Microprocessor Controller Operation 7
2.7.1 Controls and Indicators 8
2.7.2 Fuses and Terminal Strips 9
2.7.3 Auxiliary Fault Lamp Conditions 10
2.7.4 Starting the Generator Set 10
2.7.5 Stopping the Generator Set 10
2.7.6 Prime Power Mode Operation 11
2.7.7 Fault Shutdowns 11
2.7.8 Controller Resetting Procedure (Following Fault Shutdown) 12
2.7.9 Resetting the Emergency Stop Switch 12
2.8 Expanded Decision-Maker™ 1 Controller Operation 13
2.8.1 Controls and Indicators 13
2.8.2 Starting the Generator Set 14
2.8.3 Stopping the Generator Set 14
2.8.4 Fault Shutdowns 14
2.8.5 Controller Resetting Procedure (Following Fault Shutdown) 14
2.9 Standard Decision-Maker™ 1 Controller Operation 15
2.9.1 Controls and Indicators 15
2.9.2 Starting the Generator Set 15
2.9.3 Stopping the Generator Set 15
2.9.4 Fault Shutdowns 16
2.9.5 Controller Resetting Procedure (Following Fault Shutdown) 16

Section 3 Scheduled Maintenance **17**

3.1 General Maintenance 17
3.2 Generator Bearing 18
3.3 Storage Procedure 18
3.3.1 Lubrication System 18
3.3.2 Cooling System 18
3.3.3 Fuel System 18
3.3.4 Exterior 18
3.3.5 Battery 18

Section 4 General Troubleshooting **19**

Table of Contents, continued

Section 5 Decision-Maker™ 3+ Troubleshooting 23
5.1 Decision-Maker™ 3+ Controller 23
5.1.1 Decision-Maker 3+ Circuit Board Terminal/Connector Identification ... 25
5.1.2 Fault Shutdowns, Decision-Maker 3+ Controller 31
5.2 Microprocessor Controller Relay Descriptions 32
5.2.1 K1 Relay, Starter Solenoid 32
5.2.2 K2 Relay, Crank Relay on Main Circuit Board 32
5.2.3 K3 Relay, Run Relay on Main Circuit Board 32
5.2.4 K4 Relay, Emergency Stop Relay on Main Circuit Board 32
5.2.5 K5 Relay, Governor Control Relay 32
5.3 Microprocessor Controller 32
5.3.1 Troubleshooting 33
5.3.2 Fuses 34
5.4 FASTCHECK Features and Operation 39
5.4.1 Features 39
5.4.2 Application 40
5.4.3 Connect/Operate Procedure 40
5.4.4 Overcrank 41
5.4.5 Controller Speed Sensor Circuitry 41
5.4.6 Generator Condition Indicator Terminal (TB1 Terminal Strip) 42

Section 6 Decision-Maker™ 1 Controller Troubleshooting 45
6.1 Decision-Maker™ 1 and Decision-Maker™ 1 Expanded Relay Controller 45
6.2 Relay Controller 52

Section 7 Component Testing and Adjustment 57
7.1 Generator Troubleshooting 57
7.2 Generator Testing 60
7.2.1 No Output On Any Phase 60
7.2.2 Overvoltage 62
7.2.3 Fluctuating Voltage 62
7.3 LED Circuit Board Test 62
7.4 SCR Assembly and Photo Transistor Board 64
7.4.1 Concept and Equipment 64
7.4.2 SCR Assembly and Photo Transistor Board Test 64
7.5 Automatic Voltage Regulator (AVR) Operation and Adjustment 66
7.6 Stator 68
7.7 Generator Field 69
7.8 Exciter Armature 70
7.9 End Bracket Removal and Replacement 72
7.10 Speed Sensor Test 73
7.11 Current Transformers 73
7.11.1 Function and Application 73
7.11.2 Testing 74
7.12 Reactive Droop Compensator 74
7.12.1 Function and Application 74
7.12.2 Initial Adjustment 74
7.12.3 Final Adjustment 75
7.12.4 Testing 75
7.13 Gauge Senders 76
7.13.1 Oil Pressure Sender Testing 76
7.13.2 Water Temperature Sender Testing 76

7.14 Governor Adjustment 77
7.14.1 Mechanical Governor 77
7.14.2 Electronic Governor, Barber-Colman Dyna 2500 125–150 kW John Deere Engine-Powered 6081 77
7.14.3 Electronic Governor, Barber-Colman Dyna 70025 using Stanadyne D Series Injection Pump 35–99 kW John Deere-Engine Powered 4045 and 6068 80

Section 8 Disassembly/Reassembly 83
8.1 Disassembly 87
8.2 Reassembly 89

Section 9 Wiring Diagrams 95
9.1 Voltage Reconnection 116
9.1.1 Introduction 116
9.1.2 Voltage Reconnection Procedure 116
9.2 Overvoltage Shutdown Adjustment 119
9.3 Generator Set Frequency Change and Adjustment 121
9.3.1 Frequency Change 121
9.3.2 Frequency Adjustment 121

Appendix A Abbreviations A-1
Appendix B Common Hardware Application Guidelines A-3
Appendix C General Torque Specifications A-4
Appendix D Common Hardware Identification A-5
Appendix E Common Hardware List A-6
Appendix F Operating Hour Service Log A-8

IMPORTANT SAFETY INSTRUCTIONS. Electromechanical equipment, including generator sets, transfer switches, switchgear, and accessories, can cause bodily harm and pose life-threatening danger when improperly installed, operated, or maintained. To prevent accidents be aware of potential dangers and act safely. Read and follow all safety precautions and instructions. SAVE THESE INSTRUCTIONS.

This manual has several types of safety precautions and instructions: Danger, Warning, Caution, and Notice.

DANGER

Danger indicates the presence of a hazard that ***will cause severe personal injury, death***, or ***substantial property damage***.

WARNING

Warning indicates the presence of a hazard that ***can cause severe personal injury, death,*** or ***substantial property damage***.

CAUTION

Caution indicates the presence of a hazard that ***will*** or ***can cause minor personal injury*** or ***property damage***.

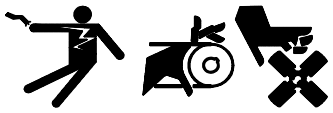
NOTICE

Notice communicates installation, operation, or maintenance information that is safety related but not hazard related.

Safety decals affixed to the equipment in prominent places alert the operator or service technician to potential hazards and explain how to act safely. The decals are shown throughout this publication to improve operator recognition. Replace missing or damaged decals.

Accidental Starting

WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

Battery

WARNING

Sulfuric acid in batteries.
Can cause severe injury or death.

Wear protective goggles and clothing. Battery acid may cause blindness and burn skin.

Battery electrolyte is a diluted sulfuric acid. Battery acid can cause severe injury or death. Battery acid can cause blindness and burn skin. Always wear splashproof safety goggles, rubber gloves, and boots when servicing the battery. Do not open a sealed battery or mutilate the battery case. If battery acid splashes in the eyes or on the skin, immediately flush the affected area for 15 minutes with large quantities of clean water. Seek immediate medical aid in the case of eye contact. Never add acid to a battery after placing the battery in service, as this may result in hazardous spattering of battery acid.

Battery acid cleanup. Battery acid can cause severe injury or death. Battery acid is electrically conductive and corrosive. Add 500 g (1 lb.) of bicarbonate of soda (baking soda) to a container with 4 L (1 gal.) of water and mix the neutralizing solution. Pour the neutralizing solution on the spilled battery acid and continue to add the neutralizing solution to the spilled battery acid until all evidence of a chemical reaction (foaming) has ceased. Flush the resulting liquid with water and dry the area.

Battery gases. Explosion can cause severe injury or death. Battery gases can cause an explosion. Do not smoke or permit flames or sparks to occur near a battery at any time, particularly when it is charging. Do not dispose of a battery in a fire. To prevent burns and sparks that could cause an explosion, avoid touching the battery terminals with tools or other metal objects. Remove all jewelry before servicing the equipment. Discharge static electricity from your body before touching batteries by first touching a grounded metal surface away from the battery. To avoid sparks, do not disturb the battery charger connections while the battery is charging. Always turn the battery charger off before disconnecting the battery connections. Ventilate the compartments containing batteries to prevent accumulation of explosive gases.

Battery short circuits. Explosion can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage. Disconnect the battery before generator set installation or maintenance. Remove all jewelry before servicing the equipment. Use tools with insulated handles. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery. Never connect the negative (-) battery cable to the positive (+) connection terminal of the starter solenoid. Do not test the battery condition by shorting the terminals together.

Engine Backfire/Flash Fire

⚠ WARNING

Fire.
Can cause severe injury or death.

Do not smoke or permit flames or sparks near fuels or the fuel system.

Servicing the fuel system. A flash fire can cause severe injury or death. Do not smoke or permit flames or sparks near the carburetor, fuel line, fuel filter, fuel pump, or other potential sources of spilled fuels or fuel vapors. Catch fuels in an approved container when removing the fuel line or carburetor.

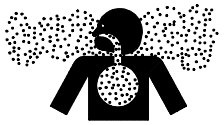
Servicing the air cleaner. A sudden backfire can cause severe injury or death. Do not operate the generator set with the air cleaner/silencer removed.

Combustible materials. A sudden flash fire can cause severe injury or death. Do not smoke or permit flames or sparks near the fuel system. Keep the compartment and the generator set clean and free of debris to minimize the risk of fire. Wipe up spilled fuels and engine oil.

Combustible materials. A fire can cause severe injury or death. Generator set engine fuels and fuel vapors are flammable and explosive. Handle these materials carefully to minimize the risk of fire or explosion. Equip the compartment or nearby area with a fully charged fire extinguisher. Select a fire extinguisher rated ABC or BC for electrical fires or as recommended by the local fire code or an authorized agency. Train all personnel on fire extinguisher operation and fire prevention procedures.

Exhaust System

⚠ WARNING



Carbon monoxide.
Can cause severe nausea, fainting, or death.

The exhaust system must be leakproof and routinely inspected.

Carbon monoxide symptoms. Carbon monoxide can cause severe nausea, fainting, or death. Carbon monoxide is a poisonous gas present in exhaust gases. Carbon monoxide poisoning symptoms include but are not limited to the following:

- Light-headedness, dizziness
- Physical fatigue, weakness in joints and muscles
- Sleepiness, mental fatigue, inability to concentrate or speak clearly, blurred vision
- Stomachache, vomiting, nausea

If experiencing any of these symptoms and carbon monoxide poisoning is possible, seek fresh air immediately and remain active. Do not sit, lie down, or fall asleep. Alert others to the possibility of carbon monoxide poisoning. Seek medical attention if the condition of affected persons does not improve within minutes of breathing fresh air.

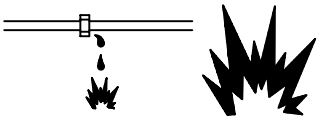
Copper tubing exhaust systems. Carbon monoxide can cause severe nausea, fainting, or death. Do not use copper tubing in diesel exhaust systems. Sulfur in diesel exhaust causes rapid deterioration of copper tubing exhaust systems, resulting in exhaust/water leakage.

Inspecting the exhaust system. Carbon monoxide can cause severe nausea, fainting, or death. For the safety of the craft's occupants, install a carbon monoxide detector. Consult the boat builder or dealer for approved detector location and installation. Inspect the detector before each generator set use. In addition to routine exhaust system inspection, test the carbon monoxide detector per the manufacturer's instructions and keep the detector operational at all times.

Operating the generator set. Carbon monoxide can cause severe nausea, fainting, or death. Carbon monoxide is an odorless, colorless, tasteless, nonirritating gas that can cause death if inhaled for even a short time. Use the following precautions when installing and operating the generator set. Do not install the exhaust outlet where exhaust can be drawn in through portholes, vents, or air conditioners. If the generator set exhaust discharge outlet is near the waterline, water could enter the exhaust discharge outlet and close or restrict the flow of exhaust. Never operate the generator set without a functioning carbon monoxide detector. Be especially careful if operating the generator set when moored or anchored under calm conditions because gases may accumulate. If operating the generator set dockside, moor the craft so that the exhaust discharges on the lee side (the side sheltered from the wind). Always be aware of others, making sure your exhaust is directed away from other boats and buildings. Avoid overloading the craft.

Fuel System

⚠ WARNING



Explosive fuel vapors.
Can cause severe injury or death.

Use extreme care when handling, storing, and using fuels.

The fuel system. Explosive fuel vapors can cause severe injury or death. Vaporized fuels are highly explosive. Use extreme care when handling and storing fuels. Store fuels in a well-ventilated area away from spark-producing equipment and out of the reach of children. Never add fuel to the tank while the engine is running because spilled fuel may ignite on contact with hot parts or from sparks. Do not smoke or permit flames or sparks to occur near sources of spilled fuel or fuel vapors. Keep the fuel lines and connections tight and in good condition. Do not replace flexible fuel lines with rigid lines. Use flexible sections to avoid fuel line breakage caused by vibration. Do not operate the generator set in the presence of fuel leaks, fuel accumulation, or sparks. Repair fuel systems before resuming generator set operation.

Draining the fuel system. Explosive fuel vapors can cause severe injury or death. Spilled fuel can cause an explosion. Use a container to catch fuel when draining the fuel system. Wipe up spilled fuel after draining the system.

Installing the fuel system. Explosive fuel vapors can cause severe injury or death. Fuel leakage can cause an explosion. Do not modify the tank or the propulsion engine fuel system. Equip the craft with a tank that allows one of the two pickup arrangements described in the installation section. The tank and installation must conform to USCG Regulations.

Pipe sealant. Explosive fuel vapors can cause severe injury or death. Fuel leakage can cause an explosion. Use pipe sealant on all threaded fittings to prevent fuel leakage. Use pipe sealant that resists gasoline, grease, lubrication oil, common bilge solvents, salt deposits, and water.

Hazardous Noise

⚠ CAUTION

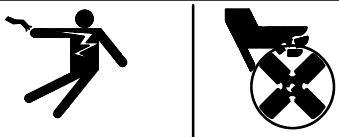
Hazardous noise.
Can cause hearing loss.

Never operate the generator set without a muffler or with a faulty exhaust system.

Engine noise. Hazardous noise can cause hearing loss. Generator sets not equipped with sound enclosures can produce noise levels greater than 105 dBA. Prolonged exposure to noise levels greater than 85 dBA can cause permanent hearing loss. Wear hearing protection when near an operating generator set.

Hazardous Voltage/ Electrical Shock

⚠ WARNING



Hazardous voltage. Moving rotor.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocution is possible whenever electricity is present. Open the main circuit breakers of all power sources before servicing the equipment. Configure the installation to electrically ground the generator set, transfer switch, and related equipment and electrical circuits to comply with applicable codes and standards. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

Disconnecting the electrical load. Hazardous voltage can cause severe injury or death. Disconnect the generator set from the load by opening the line circuit breaker or by disconnecting the generator set output leads from the transfer switch and heavily taping the ends of the leads. High voltage transferred to the load during testing may cause personal injury and equipment damage. Do not use the safeguard circuit breaker in place of the line circuit breaker. The safeguard circuit breaker does not disconnect the generator set from the load.

Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage**.** Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

Testing the voltage regulator. Hazardous voltage can cause severe injury or death. High voltage is present at the voltage regulator heat sink. To prevent electrical shock do not touch the voltage regulator heat sink when testing the voltage regulator. *(PowerBoost™, PowerBoost™ III, and PowerBoost™ V voltage regulator models only)*

Electrical backfeed to the utility. Hazardous backfeed voltage can cause severe injury or death. Connect the generator set to the building/marina electrical system only through an approved device and after the building/marina main switch is opened. Backfeed connections can cause severe injury or death to utility personnel working on power lines and/or personnel near the work area. Some states and localities prohibit unauthorized connection to the utility electrical system. Install a ship-to-shore transfer switch to prevent interconnection of the generator set power and shore power.

Testing live electrical circuits. Hazardous voltage or current can cause severe injury or death. Have trained and qualified personnel take diagnostic measurements of live circuits. Use adequately rated test equipment with electrically insulated probes and follow the instructions of the test equipment manufacturer when performing voltage tests. Observe the following precautions when performing voltage tests: (1) Remove all jewelry. (2) Stand on a dry, approved electrically insulated mat. (3) Do not touch the enclosure or components inside the enclosure. (4) Be prepared for the system to operate automatically. *(600 volts and under)*

Hot Parts

⚠ WARNING

Hot coolant and steam.
Can cause severe injury or death.

Before removing the pressure cap, stop the generator set and allow it to cool. Then loosen the pressure cap to relieve pressure.

⚠ WARNING

Hot engine and exhaust system.
Can cause severe injury or death.

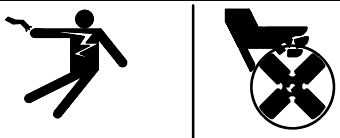
Do not work on the generator set until it cools.

Checking the coolant level. Hot coolant can cause severe injury or death. Allow the engine to cool. Release pressure from the cooling system before removing the pressure cap. To release pressure, cover the pressure cap with a thick cloth and then slowly turn the cap counterclockwise to the first stop. Remove the cap after pressure has been completely released and the engine has cooled. Check the coolant level at the tank if the generator set has a coolant recovery tank.

Servicing the exhaust system. Hot parts can cause severe injury or death. Do not touch hot engine parts. The engine and exhaust system components become extremely hot during operation.

Moving Parts

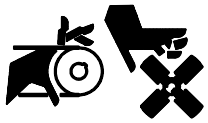
⚠ WARNING



Hazardous voltage. Moving rotor.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

⚠ WARNING



Rotating parts.
Can cause severe injury or death.

Operate the generator set only when all guards, screens, and covers are in place.

⚠ WARNING

Airborne particles.
Can cause severe injury or blindness.

Wear protective goggles and clothing when using power tools, hand tools, or compressed air.

Tightening the hardware. Flying projectiles can cause severe injury or death. Loose hardware can cause the hardware or pulley to release from the generator set engine and can cause personal injury. Retorque all crankshaft and rotor hardware after servicing. Do not loosen the crankshaft hardware or rotor thrubolt when making adjustments or servicing the generator set. Rotate the crankshaft manually in a clockwise direction only. Turning the crankshaft bolt or rotor thrubolt counterclockwise can loosen the hardware.

Servicing the generator set when it is operating. Exposed moving parts can cause severe injury or death. Keep hands, feet, hair, clothing, and test leads away from the belts and pulleys when the generator set is running. Replace guards, screens, and covers before operating the generator set.

Sound shield removal. Exposed moving parts can cause severe injury or death. The generator set must be operating in order to perform some scheduled maintenance procedures. Be especially careful if the sound shield has been removed, leaving the belts and pulleys exposed. *(Sound-shield-equipped models only)*

Notice

NOTICE

This generator set has been rewired from its nameplate voltage to

246242

NOTICE

Voltage reconnection. Affix a notice to the generator set after reconnecting the set to a voltage different from the voltage on the nameplate. Order voltage reconnection decal 246242 from an authorized service distributor/dealer.

NOTICE

Hardware damage. The engine and generator set may use both American Standard and metric hardware. Use the correct size tools to prevent rounding of the bolt heads and nuts.

NOTICE

When replacing hardware, do not substitute with inferior grade hardware. Screws and nuts are available in different hardness ratings. To indicate hardness, American Standard hardware uses a series of markings, and metric hardware uses a numeric system. Check the markings on the bolt heads and nuts for identification.

NOTICE

Fuse replacement. Replace fuses with fuses of the same ampere rating and type (for example: 3AB or 314, ceramic). Do not substitute clear glass-type fuses for ceramic fuses. Refer to the wiring diagram when the ampere rating is unknown or questionable.

NOTICE

Saltwater damage. Saltwater quickly deteriorates metals. Wipe up saltwater on and around the generator set and remove salt deposits from metal surfaces.

Notes

Introduction

This manual provides troubleshooting and repair instructions for 40COZ/33CFOZ, 40EOZ/33EFOZ, 50COZ/40CFOZ, 50EOZ/40EFOZ, 65COZ/50CFOZ, 65EOZ/55EFOZ, 80EOZ/70EFOZ, 99EOZ/80EFOZ, 125EOZ/100EFOZ, and 150EOZ/125EFOZ model generator sets, controllers, and accessories.

Refer to the engine service manual for generator set engine service information.

x:in:001:001

This manual may be used for models not listed on the front cover.

Information in this publication represents data available at the time of print. Kohler Co. reserves the right to change this publication and the products represented without notice and without any obligation or liability whatsoever.

Read this manual and carefully follow all procedures and safety precautions to ensure proper equipment operation and to avoid bodily injury. Read and follow the Safety Precautions and Instructions section at the beginning of this manual. Keep this manual with the equipment for future reference.

The equipment service requirements are very important to safe and efficient operation. Inspect the parts often and perform required service at the prescribed intervals. Obtain service from an authorized service distributor/dealer to keep equipment in top condition.

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Service Assistance

Please contact a local authorized distributor/dealer for sales, service, or other information about Kohler Co. Generator Division products.

- Look on the product or in the information included with the product
- Consult the Yellow Pages under the heading Generators—Electric
- Visit the Kohler Co. Generator Division web site at www.kohlergenerators.com
- Inside the U.S.A. and Canada, call 1-800-544-2444
- Outside the U.S.A. and Canada, call the nearest regional office

Africa, Europe, Middle East
London Regional Office
Langley, Slough, England
Phone: (44) 1753-580-771
Fax: (44) 1753-580-036

Australia
Australia Regional Office
Queensland, Australia
Phone: (617) 3893-0061
Fax: (617) 3893-0072

China
China Regional Office
Shanghai, People's Republic of China
Phone: (86) 21-6482 1252
Fax: (86) 21-6482 1255

India, Bangladesh, Sri Lanka
India Regional Office
Bangalore, India
Phone: (91) 80-2284270
(91) 80-2284279
Fax: (91) 80-2284286

Japan
Japan Regional Office
Tokyo, Japan
Phone: (813) 3440-4515
Fax: (813) 3440-2727

Latin America
Latin America Regional Office
Lakeland, Florida, U.S.A.
Phone: (941) 619-7568
Fax: (941) 701-7131

South East Asia
Singapore Regional Office
Singapore, Republic of Singapore
Phone: (65) 264-6422
Fax: (65) 264-6455

X:in:008:001

Notes

1.1 Introduction

The spec sheets for each generator set provide specific generator and engine information. Refer to the respective spec sheet for data not supplied in this manual. Consult the generator set operation manual, generator installation manual, engine operation manual, and engine service manual for additional specifications.

1.2 Specifications

The generator set consists of a rotating-field generator combined with a smaller rotating-armature generator turned by a common shaft. The main rotating-field generator supplies current to the load circuits while the rotating-armature (exciter) generator supplies rectified AC (DC) to excite the main generator's field.

Engine		
Engine Prealarm and Shutdown Switches	**Specification COZ/CFOZ and EOZ/EFOZ Models**	
Anticipatory high engine temperature switch	96° C (205° F) ±7	
Anticipatory low oil pressure switch	138 kPa ±14 kPa (20 psi ±2)	
High engine temperature shutdown switch	103° C (218° F) ±7	
Low oil pressure shutdown switch	103 kPa ±14 kPa (15 psi ±2)	
High exhaust temperature switch (wet exhaust only)	88–102° C (190–215° F) ±5	
Controller Gauge Senders	**Specification (in ohms) COZ/CFOZ Models**	**Specification (in ohms) EOZ/EFOZ Models**
Oil Pressure Sender		
0 kPa (0 psi)	120 (+9/–8)	240 (+17/–15)
172 kPa (25 psi)	76.5 (+6/–7.5)	153 (+12/–15)
690 kPa (100 psi)	16.8	33.5
Water Temperature Sender		
54° C (130° F)	100 ±15	180 ±12
82° C (180° F)	40 ±6	71 ±8

Generator	
Component Specification	**Value**
Controller/battery electrical system	12 or 24 volts DC
Generator field resistance (F+/ F–):	
40/50COZ and 33/40CFOZ	2.0–2.9 ohms
65COZ and 50CFOZ	1.8–2.2 ohms
40EOZ and 33EFOZ	2.1–2.5 ohms
50EOZ and 40EFOZ	2.7–3.1 ohms
65/80EOZ and 55/70EFOZ	1.7–2.1 ohms
99EOZ and 80EFOZ	2.0–2.4 ohms
125EOZ and100EFOZ	1.4–1.8 ohms
150EOZ and 125EFOZ	1.6–2.0 ohms
Exciter armature resistance:	
40/50COZ and 33/40CFOZ	0.13 ohms
65COZ and 50CFOZ	0.27 ohms
40EOZ and 33EFOZ	0.23 ohms
50EOZ and 40EFOZ	0.14 ohms
65/80EOZ and 55/70EFOZ	0.27 ohms
99EOZ and 80EFOZ	0.27 ohms
125EOZ and100EFOZ	0.27 ohms
150EOZ and 125EFOZ	0.27 ohms
SCR assembly terminal nut torque	1.4 Nm (12 in. lbs.)
Fan to rotor flange torque	29 Nm (260 in. lbs.)
Drive disks to rotor shaft torque	61 Nm (45 ft. lbs.)
Speed sensor air gap	0.36–0.71 mm (0.014–0.028 in.)
Speed sensor voltage	2 (black) & 16 (white) 3–6 volts DC 2 (black) & 24 (red) 8–10 volts DC
Electronic governor magnetic pickup air gap	0.36–0.71 mm (0.014–0.028 in.)
Magnetic pickup output voltage during cranking	2.5 volts AC min.
Flex plate to flywheel bolt torque (3/8-16)	52.9 Nm (39 ft. lbs.)

1.3 Accessories

Kohler Co. offers several accessories to finalize the installation and to add convenience to operation and service. Accessories vary with each generator set model and controller. Kohler Co. offers accessories factory-installed and/or shipped loose. Some accessories are available only with microprocessor controllers. Obtain current information by contacting your local authorized service distributor/dealer. Several accessories available at the time of print of this publication are detailed in the following subsections.

1.3.1 Remote Annunciator Kit

A remote annunciator allows convenient monitoring of the generator set's condition from a remote location. See Figure 1-1. The flush-mounted annunciator panel extends all of the fault and prealarm lights/audio of the Decision-Maker 3+ controller. The remote annunciator includes an alarm horn, an alarm silence switch, a lamp test, and the same lamp indicators (except air damper and auxiliary prealarm) as the microprocessor controller, plus the following:

Line Power. Lamp illuminates to indicate the power source is shore power.

Generator Power. Lamp illuminates to indicate the power source is the generator set.

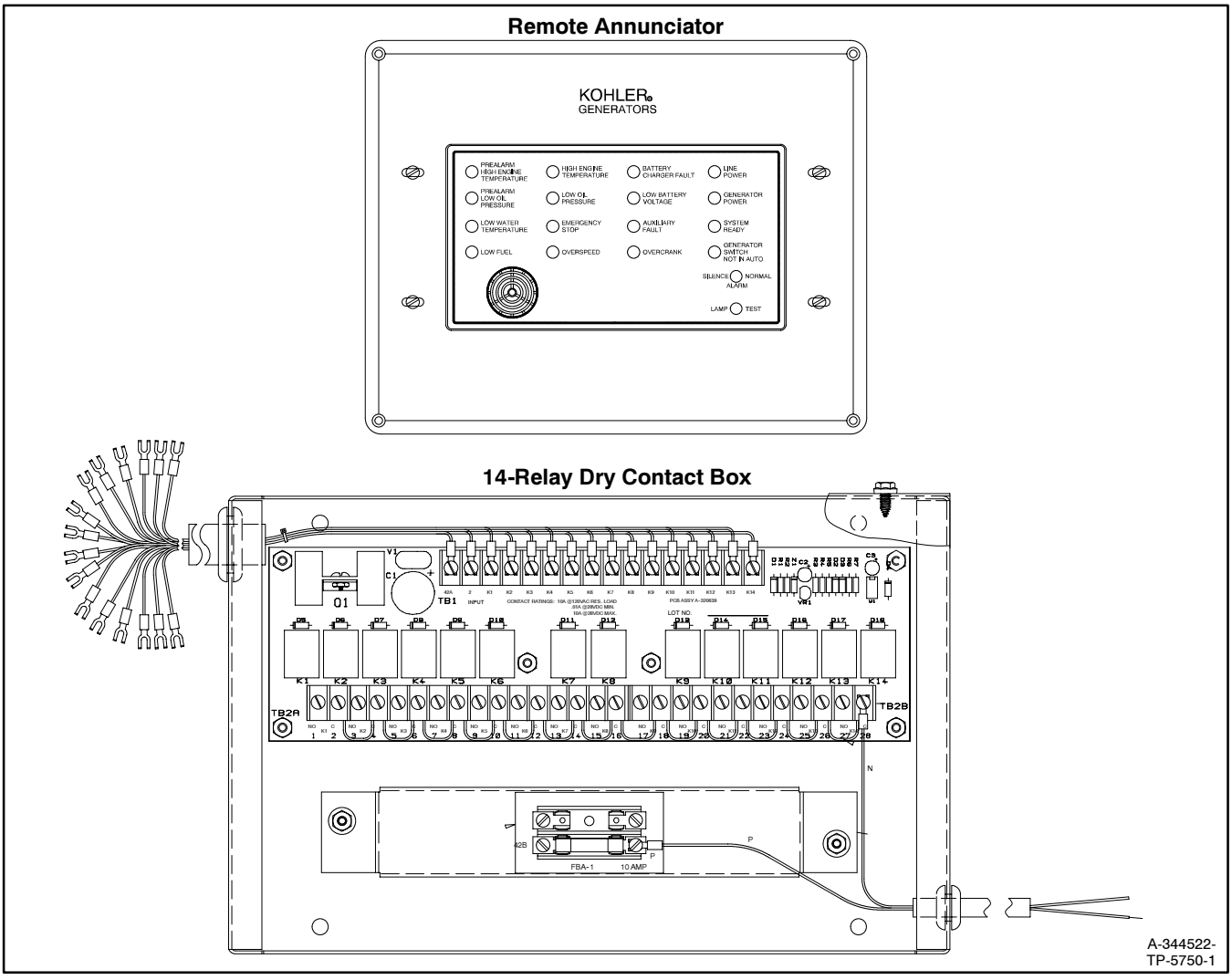


Figure 1-1 Remote Annunciator with 14-Relay Dry Contact Kit

1.3.2 Safeguard Breaker

The safeguard breaker senses output current on each generator phase and shuts off the AC voltage regulator in the event of a sustained overload or short circuit. It is not a line circuit breaker and does NOT disconnect the generator from the load. See Figure 1-2.

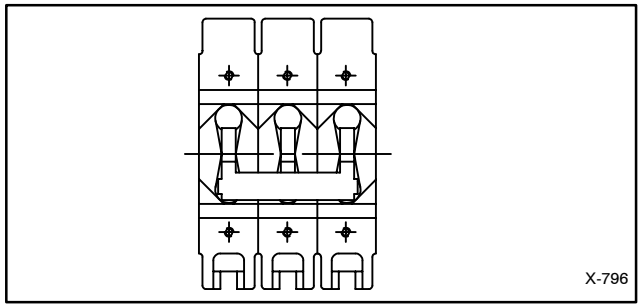


Figure 1-2 Safeguard Breaker

1.3.3 Line Circuit Breaker

The line circuit breaker interrupts generator output in the event of an overload or short circuit. Use the kit to manually disconnect the generator set from the load when servicing the generator set. See Figure 1-3.

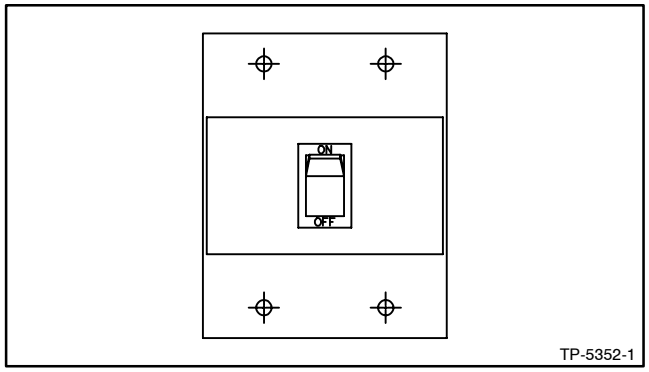


Figure 1-3 Line Circuit Breaker

1.3.4 Run Relay Kit

The run relay kit energizes only when the generator set is running. Typically, the three sets of contacts control air intake and/or compartment ventilation fans. However, alarms and other signalling devices can also connect to the contacts. See Figure 1-4.

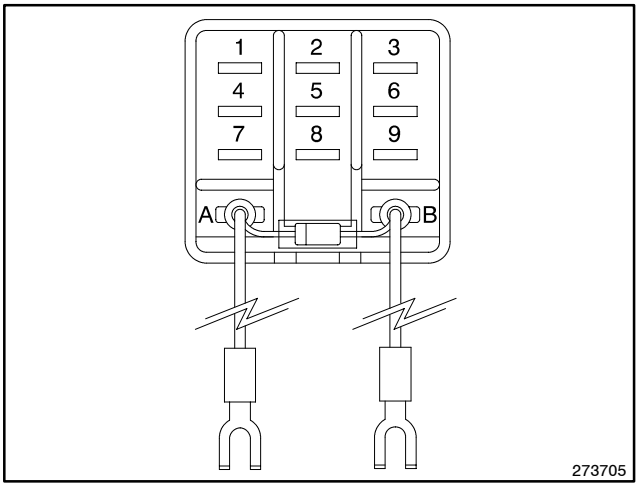


Figure 1-4 Run Relay Kit

1.3.5 FASTCHECK Diagnostic Tester (Microprocessor Controller Only)

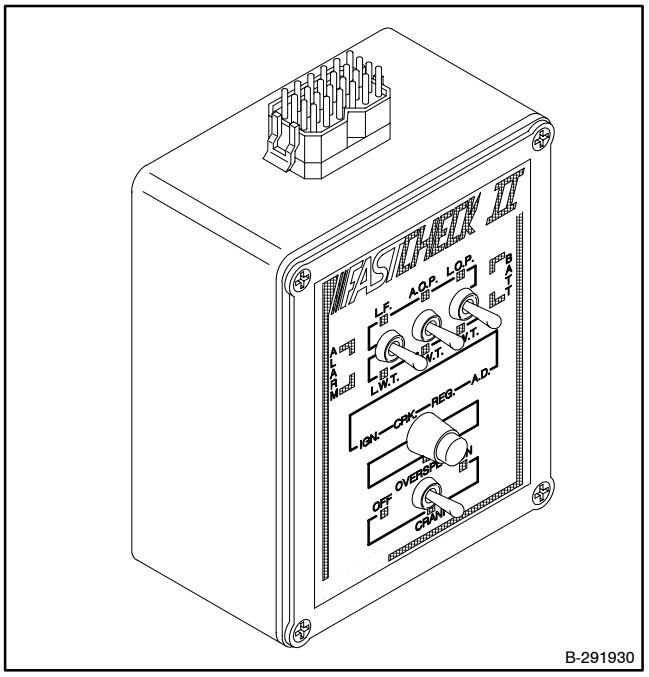
The FASTCHECK® diagnostic tester simulates engine operation to identify faults in the controller and engine circuitry. Use the FASTCHECK® when troubleshooting startup problems or to test and troubleshoot the controller when the controller is removed from the generator. Perform tests without starting the generator set. Functions performed by the FASTCHECK® are listed below; refer to Figure 1-5 to identify LEDs and switches.

LEDs on the FASTCHECK® indicate the energizing of the following circuits:

- Fuel solenoid (diesel)
- Engine crank
- AC voltage regulator
- Battery connection (correct polarity)
- Engine malfunction alarm and/or alarm shutdown

Switches on the FASTCHECK® simulate the following:

- Engine cranking
- Engine running
- Engine overspeed
- Low fuel
- Low engine coolant temperature
- Anticipatory low engine oil pressure
- Anticipatory high engine coolant temperature
- Low engine oil pressure
- High engine coolant temperature



B-291930

Figure 1-5 FASTCHECK® Diagnostic Tester

2.1 Fast-Response™ II Concepts

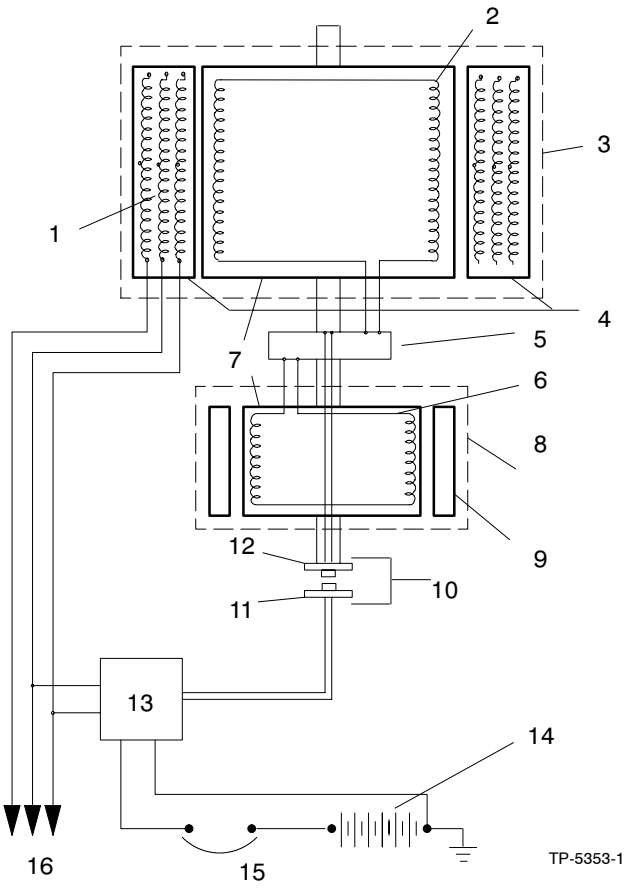
The generator excitation system uses a permanent magnet exciter with a silicon controlled rectifier (SCR) assembly that controls the amount of DC current fed to the generator field. This type of system uses a voltage regulator that signals the SCR assembly through an optocoupler. The voltage regulator monitors generator output voltage and engine speed and signals the SCR assembly to turn on or off accordingly through the optocoupler. The optical coupler consists of a light emitting diode (LED) mounted on the stationary end bracket and a photo transistor mounted on the rotating shaft. The photo transistor picks up the infrared signal from the LED and signals the SCR assembly to turn on or off, depending upon the need, as dictated by the voltage regulator. See Figure 2-1.

The voltage recovery period of this type of generator is several times faster than the conventionally wound field brushless generator because the generator set does not have to contend with the inductance of the exciter field. The generator set also has better recovery characteristics than the static-excited machine because it is not dependent upon the generator set output voltage for excitation power. Possibly the greatest advantage of this type of machine is its inherent ability to support short-circuit current and allow system coordination for tripping downstream branch circuit breakers.

The generator set systems deliver exciter current to the main field within 50 milliseconds (0.050 seconds) of a change in load demand.

2.2 Short Circuit Performance

When a short circuit occurs in the load circuit(s) being served, output voltage drops and amperage momentarily rises to 600–1000% of the generator set's rated current until removal of the short. The SCR assembly sends full exciter power to the main field. The generator then sustains up to 300% of its rated current. Sustained high current causes correspondingly rated load circuit fuses/breakers to trip. The safeguard breaker kit shuts down the excitation system in the event of a sustained heavy overload or short circuit.



1. Main armature
2. Main field
3. Main generator
4. Stator
5. SCR assembly
6. Exciter armature
7. Rotor
8. Exciter generator
9. Exciter field magnets
10. Optical coupler
11. LED board (PCB assembly)
12. Photo transistor board (PCB assembly)
13. AC voltage regulator
14. Starting battery
15. Safeguard breaker (optional)
16. Main output leads

Figure 2-1 Alternator Schematic

2.3 Prestart Checklist

To ensure continued satisfactory operation perform the following checks or inspections before or at each startup, as designated, and at the intervals specified in the service schedule. In addition, some checks require verification after the unit starts.

Air Cleaner. Check for a clean and installed air cleaner element to prevent unfiltered air from entering the engine.

Air Inlets. Check for clean and unobstructed air inlets.

Air Shrouding. Check for securely installed and positioned air shrouding.

Battery. Check for tight battery connections. Consult the battery manufacturer's instructions regarding battery care and maintenance.

Coolant Level. Check the coolant level according to the cooling system maintenance information.

Drive Belts. Check the belt condition and tension of the water pump and battery charging alternator belt(s).

Exhaust System. Check for exhaust leaks and blockages. Check the silencer and piping condition and check for tight exhaust system connections.

Inspect the exhaust system components (exhaust manifold, mixing elbow, exhaust line, hose clamps, silencer, and exhaust outlet) for cracks, leaks, and corrosion.

- Check the hoses for softness, cracks, leaks, or dents. Replace the hoses as needed.
- Check for corroded or broken metal parts and replace them as needed.
- Check for loose, corroded, or missing clamps. Tighten or replace the hose clamps as needed.
- Check that the exhaust outlet is unobstructed.
- Visually inspect for exhaust leaks *(blowby)*. Check for carbon or soot residue on exhaust components. Carbon and soot residue indicates an exhaust leak. Seal leaks as needed.
- Ensure that the carbon monoxide detector is (1) in the craft, (2) functional, and (3) energized whenever the generator set operates.

Fuel Level. Check the fuel level and keep the tank(s) full to ensure adequate fuel supply.

Oil Level. Maintain the oil level at or near, not over, the full mark on the dipstick.

Operating Area. Check for obstructions that could block the flow of cooling air. Keep the air intake area clean. Do not leave rags, tools, or debris on or near the generator set.

Seawater Pump Priming. Prime the seawater pump before initial startup. To prime the pump: (1) close the seacock, (2) remove the hose from the water-filter outlet, (3) fill the hose and seawater pump with clean water, (4) reconnect the hose to the water filter outlet, and (5) open the seacock. Confirm sea water pump operation on startup as indicated by water discharge from the exhaust outlet.

2.4 Marine Inspection

Kohler Co. recommends that all boat owners have their vessels—especially the exhaust system attached to the generator set—inspected at the start of each boating season by the local Coast Guard Auxiliary. If there is no Coast Guard Auxiliary in the area, contact an authorized Kohler distributor/dealer for the inspection.

m:op:001:003

2.5 Angular Operation

See Figure 2-2 for angular operation limits for units covered in this manual.

Continuous	Intermittent— 3 minutes or less
25°	30°
Maximum value for all directions	

Figure 2-2 Angular Operation

m:op:001:004

2.6 Exercising the Generator Set

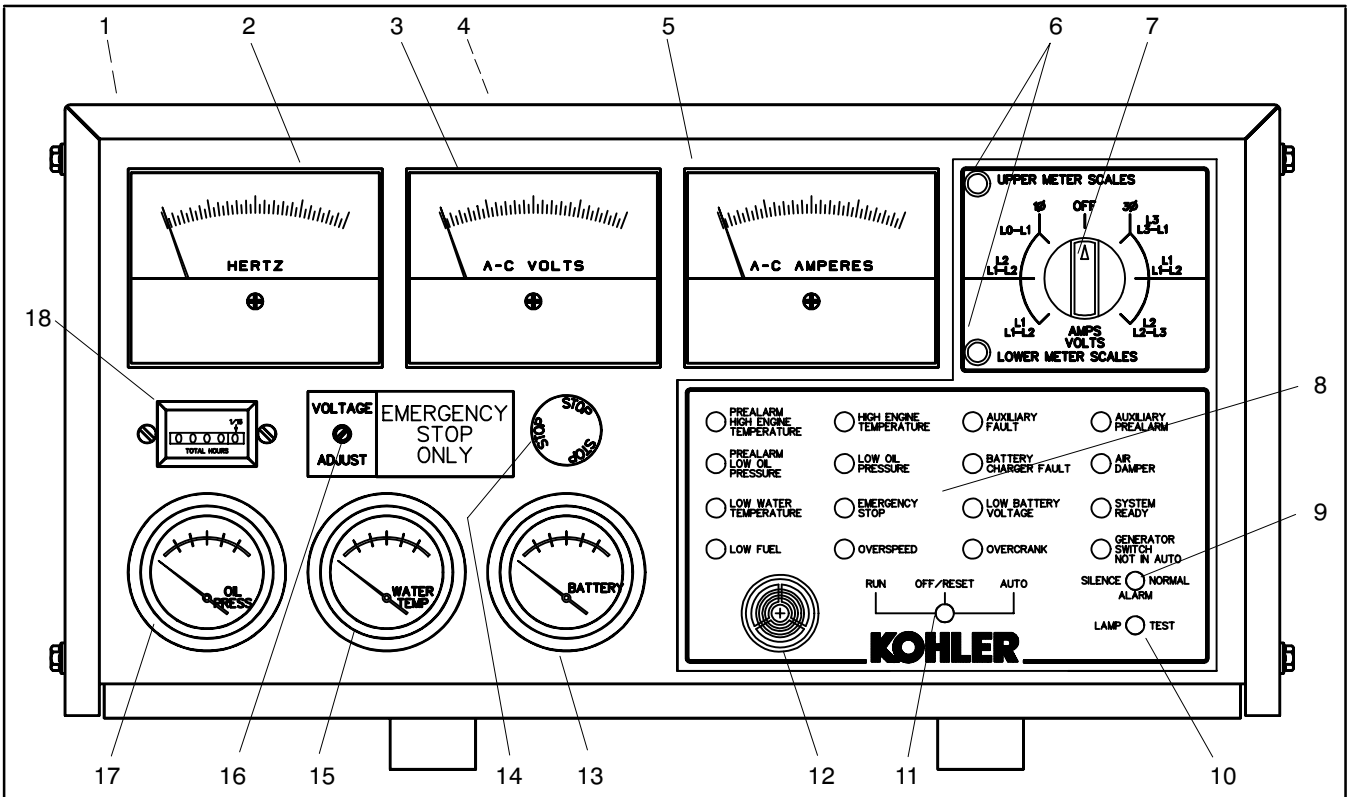
Operate the generator set under load once each week for one hour with an operator present.

The operator should perform all of the prestart checks before starting the exercise procedure. Start the generator set according to the starting procedure in the controller section of this manual. While the generator set is operating, listen for a smooth-running engine and visually inspect the generator set for fluid or exhaust leaks.

x:op:001:005

2.7 Decision-Maker™ 3+ 16-Light Microprocessor Controller Operation

Figure 2-3 identifies the Decision-Maker™ 3+ 16-light controller's indicators and controls and their functions.



1. Fuses (inside controller)
2. Frequency meter
3. AC voltmeter
4. Controller TB1 and TB2 terminal strips (on circuit board)
5. AC ammeter
6. Scale lamps (upper/lower)
7. Selector switch
8. Annunciator panel lamps
9. Alarm silence switch
10. Lamp test
11. Generator set master switch
12. Alarm horn
13. DC voltmeter
14. Emergency stop switch, if equipped
15. Water temperature gauge
16. Voltage adjustment
17. Oil pressure gauge
18. Hourmeter

Figure 2-3 Decision-Maker™ 3+, 16-Light Microprocessor Controller

2.7.1 Controls and Indicators

The following table describes the controls and indicators located on the controller.

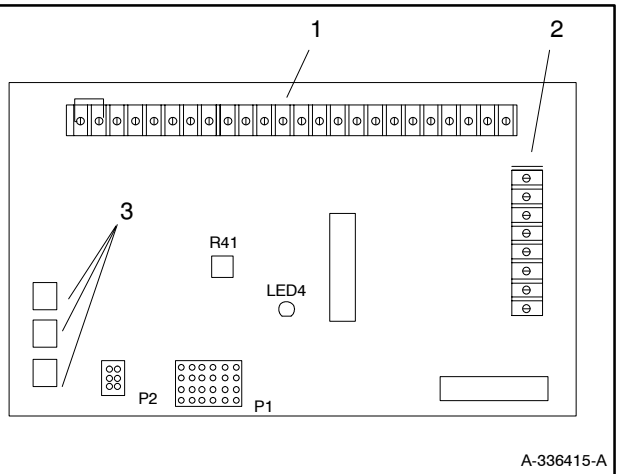
Name	Description
AC ammeter	The meter displays the AC output amperage. Use the selector switch to choose the phase current.
AC voltmeter	The meter displays the AC output voltage. Use the selector switch to choose the output lead circuits.
DC voltmeter	The meter displays the voltage of the starting battery(ies).
Alarm horn	The horn sounds if any fault or anticipatory condition exists. Place the generator set master switch in the AUTO position before silencing the horn. See the Controller Resetting Procedure later in this section.
Alarm silence switch	The switch disconnects the alarm during service (place the generator set master switch in the AUTO position before silencing the alarm horn). Restore the alarm horn switches at all locations (controller, remote annunciator, and audio/visual alarm) to normal positions after correcting the fault shutdown to avoid reactivating the alarm horn. See the Controller Resetting Procedure later in this section.
Auxiliary fault lamp	The lamp flashes or lights when the controller detects a fault. See the lamp conditions section following.
Frequency meter	The meter displays the frequency (Hz) of the generator set output voltage.
Generator set master switch	The switch functions as the controller reset and generator set operation switch.
High engine temperature lamp	The lamp illuminates if the generator set shuts down because of high engine temperature. Shutdown occurs 5 seconds after the engine reaches temperature shutdown range.
Hourmeter	The hourmeter records the generator set total operating hours for reference in maintenance scheduling.
Lamp test switch	The switch tests the controller indicator lamps.
Low oil pressure lamp	The lamp illuminates if the generator set shuts down because of low oil pressure. Shutdown occurs 5 seconds after the engine reaches oil pressure shutdown range.
Overcrank lamp	The lamp illuminates and cranking stops if the engine does not start after 45 seconds of continuous cranking or 75 seconds of cyclic cranking. The cranking stops and overcrank lamp lights after 15 seconds if the starter or engine does not turn (locked rotor). The overcrank lamp flashes if the speed sensor signal is absent longer than one second. **NOTE:** The generator set controller's automatic restart function attempts to restart the generator set if the engine speed drops below 13 Hz (390 rpm). Continued decreased engine speed causes an overcrank condition.
Overspeed lamp	The lamp illuminates if the generator set shuts down because governed frequency on 50 and 60 Hz models exceeds 70 Hz.
Water temperature gauge	The gauge displays the engine coolant temperature.
Oil pressure gauge	The gauge displays the engine oil pressure.
Scale lamps (upper/lower)	The lamps indicate which AC voltmeter and/or ammeter scales to read.
Selector switch	The switch selects the generator set output circuits to measure. When switched to a position with two circuit labels, measure amperage on the lead shown in the upper label and measure voltage between the two leads shown in the lower label. The AC ammeter and voltmeter function only with the switch in the ON position.
Voltage adjustment potentiometer	The potentiometer fine-tunes (±5%) the generator set output voltage.

Name	Description
Auxiliary prealarm lamp	The lamp illuminates when customer-provided sensing devices activate the pump.
Emergency stop lamp	The lamp illuminates and the generator set shuts down when energizing the optional emergency stop switch. The lamp needs the optional emergency stop switch to function.
Generator switch not in auto lamp	The lamp illuminates when the generator set master switch is in the RUN or OFF/RESET position.
Low fuel lamp	The lamp illuminates when the fuel level in the tank approaches empty. The lamp needs a low fuel sensor in the fuel tank to function.
High water temperature lamp	The lamp illuminates when the water temperature approaches shutdown range. The lamp needs an optional prealarm sender kit to function.
Prealarm high engine temperature lamp	The lamp illuminates when the engine coolant temperature approaches shutdown range. The lamp needs an optional prealarm sender kit to function.
Prealarm low oil pressure lamp	The lamp illuminates when the engine oil pressure approaches shutdown range. The lamp needs an optional prealarm sender kit to function.
System ready lamp	The lamp illuminates when the generator set master switch is in AUTO position and the system senses no faults.
Emergency stop switch	The switch, if activated, instantly shuts down the generator set in emergency situations. Use the emergency stop switch for emergency shutdowns only. Use the generator set master switch for normal shutdowns.

2.7.2 Fuses and Terminal Strips

The following table describes the controller circuit board fuses and controller terminal strips.

Name	Description
3-amp remote annunciator fuse	The fuse protects the remote annunciator circuit, A/V alarm, and isolated alarm kit, if equipped.
3-amp controller fuse	The fuse protects the controller circuit board, speed sensor, and lamp circuit board.
15-amp engine and accessories fuse	The fuse protects the engine/starting circuitry and accessories.
Controller TB1 terminal strip	The terminal strip provides connection points for customer-supplied sensing devices and generator set accessories such as the emergency stop switch, remote start stop/switch, audio/visual alarms, etc., to the controller. Figure 2-4 shows the location of the TB1 terminal strip on the controller circuit board. Refer to the wiring diagrams for information on connecting accessories to the TB1 terminal strip.
Controller TB2 terminal strip	The terminal strip provides connection points for crank mode selection (cyclic or continuous) and remote start/stop switch inputs of operation. Figure 2-4 shows the location of the TB2 terminal strip on the controller circuit board. Refer to the wiring diagrams for connection information.



1. TB1 terminal strip
2. TB2 terminal strip
3. Fuses

Figure 2-4 TB1 and TB2 Terminal Strips on Decision-Maker™ 3+ Controller Circuit Board

2.7.3 Auxiliary Fault Lamp Conditions

The following descriptions define the possible auxiliary fault lamp conditions.

Flashing Lamp Conditions

No AC Output. The auxiliary lamp flashes immediately if the controller senses no AC output while the generator set runs (except during the first 10 seconds after startup). The flashing stops and the light goes out when the controller senses AC output. The controller requires no manual reset.

Low Battery Voltage. The auxiliary lamp flashes if the battery power was reconnected or was low and then restored while the generator set master switch was in the RUN or AUTO position. A possible cause is a temporary low battery condition when the battery is weak or undersized for the application. To clear the low battery voltage condition, place the generator set master switch in the OFF/RESET position.

Continuous-On Lamp Conditions

Emergency Stop Switch Energized. Upon activation of the emergency stop switch, if equipped, the auxiliary lamp lights and the generator set shuts down immediately.

Emergency Stop Switch Reset. Resetting the optional emergency stop switch while the generator set master switch is in the AUTO or RUN position causes the auxiliary lamp to light. Place the generator set master switch in the OFF/RESET position to clear the auxiliary lamp ON condition.

Note: Auxiliary Delay Shutdown. The auxiliary lamp lights and the engine shuts down 5 seconds after the high oil temperature (P1-13) or auxiliary delay shutdown (P1-15) fault, if equipped, occurs. Auxiliary Delay Shutdown is inhibited during the first 30 seconds after crank disconnect.

Note: Overvoltage Shutdown. If a generator set is equipped with this kit, the auxiliary lamp lights and the engine shuts down immediately when an overvoltage condition occurs.

Note: Auxiliary Immediate Shutdown. The auxiliary lamp lights and the engine shuts down immediately when any customer-supplied sensing devices connected to auxiliary immediate shutdown ports (P1-17 and P1-18) activate them.

x:op:005:004

2.7.4 Starting the Generator Set

The following procedures describe starting the generator set.

Local Starting (Nonautomatic). Move the generator set master switch to the RUN position to start the generator set at the controller.

Note: The alarm horn sounds whenever the generator set master switch is not in the AUTO position.

Automatic (Auto) Starting. Move the generator set master switch to the AUTO position to allow startup by the automatic transfer switch or remote start/stop switch (connected to controller terminals TB1-3 and TB1-4).

Note: The transient start/stop function of the Decision-Maker™ 3+ controller prevents accidental cranking of the rotating engine. When the generator set master switch is momentarily placed in the OFF/RESET position, then quickly returned to RUN, the generator set slows to 249 rpm and then recranks before returning to rated speed.

Note: The Decision-Maker™ 3+ controller's automatic restart function attempts to restart the generator set if the engine speed drops below 390 rpm (generator output frequency of 13 Hz). Continued decreased engine speed causes an overcrank fault condition.

Crank Mode Selection

The Decision-Maker™ 3+ controller cranks continuously for up to 45 seconds or cyclically for up to 75 seconds (crank 15 seconds, rest 15 seconds, crank 15 seconds, etc.) before overcrank shutdown. Select the crank mode (cyclic or continuous) on the controller circuit board terminal strip. For cyclic cranking, leave circuit board terminal TB2-9 open. For continuous cranking, attach a jumper between circuit board terminal TB2-9A (ground) and terminal TB2-9.

2.7.5 Stopping the Generator Set

The following procedures describe stopping the generator set.

Normal Stopping

1. **Cooldown.** Run the generator set at no load for 5 minutes to ensure adequate engine cooldown.
2. **Stopping.** Move the generator set master switch to the OFF/RESET position. The engine stops.

Note: The generator set continues running during a 5-minute cooldown cycle if a remote switch or automatic transfer switch signals the engine to stop.

Emergency Stopping

Move the generator set master switch to the OFF/RESET position or activate the remote emergency stop, if equipped, for immediate shutdown. The controller AUXILIARY lamp lights and the generator set shuts down on activation of the emergency stop switch. The remote annunciator and/or A/V alarms, if equipped, signal an emergency stop.

2.7.6 Prime Power Mode Operation

The Decision-Maker™ 3+ controller operates in either the normal mode or the prime power mode. In prime power mode, the controller draws less current, minimizing the battery drain. Consider using the prime power mode for installations that do not have a battery charger.

Moving the generator set master switch to the OFF/RESET position disables all controller functions. Moving the generator set master switch to the AUTO position restores controller functions.

Enabling and Disabling the Prime Power Mode. Enable the prime power mode by connecting jumpers across the following terminals on terminal strip TB2 on the controller circuit board:

- TB2-1P and TB2-2P
- TB2-3P and TB2-4P
- TB2-3 and TB2-4

See Figure 2-4. Remove the jumpers listed above to disable the prime power mode.

Prime Power Starting. The prime power mode provides local starting only at the controller. When the generator set master switch is in the OFF/RESET position, the controller functions are inoperative. Move the generator set master switch to the AUTO position to start the generator set. Do not start the generator set with the master switch in the RUN position because the alarm horn sounds.

Note: Move the generator set master switch to the AUTO position to return controller functions to normal.

Prime Power Stopping. Move the generator set master switch to the OFF/RESET position to stop the generator set and power down the controller.

2.7.7 Fault Shutdowns

The generator set shuts down automatically under the following fault conditions and cannot be restarted until the fault condition is corrected. The system automatically resets when the problem is corrected or the generator set cools (if high engine temperature was the fault).

Name	Description
High engine temperature	Shutdown occurs 5 seconds after the fault. The high engine temperature shutdown does not function during the first 5 seconds after startup. **NOTE:** The high temperature shutdown functions only when the coolant level is in the operating range.
High exhaust temperature	Shutdown occurs 5 seconds after the fault. The high exhaust temperature shutdown does not function during the first 5 seconds after startup.
Low coolant level (water-cooled engines only)	Shutdown occurs 5 seconds after fault. The low coolant level shutdown does not function during the first 5 seconds after startup.
Low oil pressure	Shutdown occurs 5 seconds after the fault. The low oil pressure shutdown does not function during the first 5 seconds after startup. **NOTE:** The low oil pressure shutdown does not protect against low oil level. Check the engine oil level.
Overcrank	Shutdown occurs after 45 seconds of continuous cranking or 75 seconds of cyclic cranking (crank 15 seconds, rest 15 seconds, crank 15 seconds, etc.).
Overspeed	Shutdown occurs immediately when governed frequency on 50 and 60 Hz models exceeds 70 Hz.
Overvoltage (optional)	The generator set shuts down and the auxiliary lamp lights when voltage is 15% or more over the nominal voltage for 2 seconds or longer. **NOTE:** Overvoltage can damage sensitive equipment in less than one second. Install separate overvoltage protection on on-line equipment requiring faster shutdown.

x:op:005:007

2.7.8 Controller Resetting Procedure (Following Fault Shutdown)

Use the following procedure to restart the generator set after a fault shutdown. Refer to Resetting the Emergency Stop Switch in this section to reset the generator set after an emergency stop.

1. Place the controller alarm horn silence switch in the SILENCE position. Place the A/V annunciator alarm switch, if equipped, in the SILENCE position to stop the alarm horn. The A/V annunciator lamp stays lit. (The A/V alarm uses one lamp to indicate a fault shutdown; the respective fault lamp on the remote annunciator lights to indicate a fault condition.)

2. Disconnect the generator set from the load using the line circuit breaker or automatic transfer switch.

3. Correct the cause of the fault shutdown. See the Safety Precautions at the beginning of this section before proceeding.

4. Place the generator set master switch in the OFF/RESET position and then in the RUN position to start the generator set. The A/V annunciator alarm horn sounds and the lamp, if equipped, darkens.

5. Test operate the generator set to verify that the cause of the shutdown has been corrected.

6. Reconnect the generator set to the load via the line circuit breaker or automatic transfer switch.

7. Place the generator set master switch in the AUTO position for startup by a remote transfer switch or remote start/stop switch. Place the A/V annunciator alarm switch, if equipped, in the NORMAL position.

8. Place the generator set master switch in the AUTO position before silencing the alarm horn.

2.7.9 Resetting the Emergency Stop Switch

Use the following procedure to restart the generator set after an emergency stop switch shutdown. Refer to the Controller Resetting Procedure in this section to restart the generator set following a fault shutdown. The generator set does not crank until the operator completes the resetting procedure.

Note: The controller auxiliary lamp lights when the generator set master switch is in the RUN or AUTO position during the resetting procedure.

Procedure to Restart the Generator Set After an Emergency Stop Shutdown:

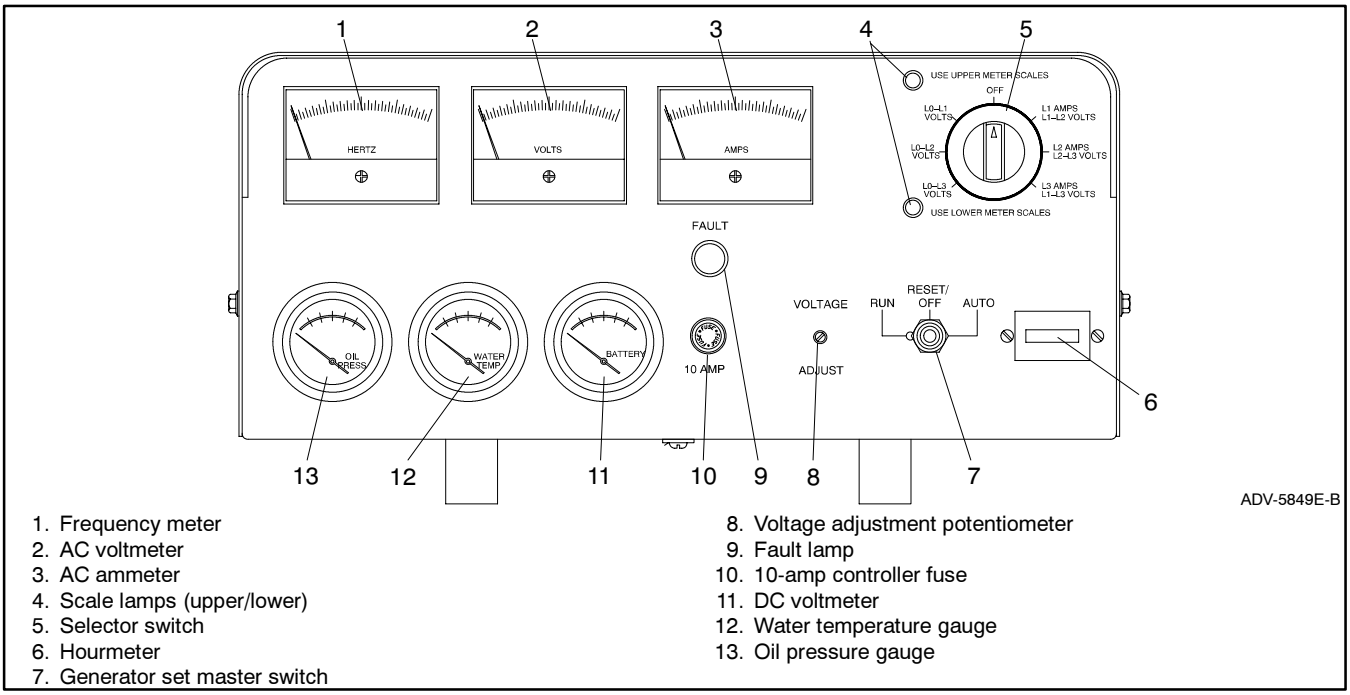
1. Determine the cause of the emergency stop and correct the problem(s).

2. Reset the controller emergency stop switch by rotating the switch clockwise until the switch springs back to the original position. See Figure 2-3.

3. Toggle the generator set master switch to OFF/RESET and then to RUN or AUTO to restart the generator set.

2.8 Expanded Decision-Maker™ 1 Controller Operation

For identification of the expanded controller's indicators and controls and their functions, refer to Figure 2-5.



1. Frequency meter
2. AC voltmeter
3. AC ammeter
4. Scale lamps (upper/lower)
5. Selector switch
6. Hourmeter
7. Generator set master switch
8. Voltage adjustment potentiometer
9. Fault lamp
10. 10-amp controller fuse
11. DC voltmeter
12. Water temperature gauge
13. Oil pressure gauge

Figure 2-5 Expanded Decision-Maker™ 1 Controller

x:op:002:001

2.8.1 Controls and Indicators

The following table describes the controls and indicators located on the controller.

Name	Description
AC voltmeter	The meter displays the AC output voltage. Use the selector switch to choose the output lead circuits.
AC ammeter	The meter displays the AC output amperage. Use the selector switch to choose the phase currents.
DC voltmeter	The meter displays the voltage of the starting battery(ies).
Fault lamp	The lamp illuminates during engine shutdown if the engine shuts down because of one of the following faults: high engine temperature, low water level, low oil pressure, overcrank, or overspeed. See Section 2.8.4, Fault Shutdowns, for additional shutdown information.
Frequency meter	The meter displays the frequency (Hz) of the generator set output.
Generator set master switch	The switch functions as the controller reset and generator set operation switch.
Hourmeter	The hourmeter records the generator set total operating hours for reference in maintenance scheduling.
Oil pressure gauge	The gauge displays the engine oil pressure.
Scale lamps (upper/lower)	The lamps indicate which AC voltmeter and/or ammeter scales to read.
Selector switch	The switch selects the generator set output circuits to measure. When switched to a position with two circuit labels, measure amperage on the lead shown in the upper label and measure voltage between the two leads shown in the lower label. The AC ammeter and voltmeter function only with the switch in the ON position.
Voltage adjustment potentiometer	The potentiometer fine-tunes (±5%) the generator set output voltage.
Water temperature gauge	The gauge displays the engine coolant temperature.
10-amp controller fuse	The fuse protects the controller circuitry from short circuits and overloads.

2.8.2 Starting the Generator Set

The following procedure describes the actions required to start the generator set.

Local Starting. Move the generator set to the RUN position to immediately start the generator set.

Auto (Automatic) Starting. Move the generator set master switch to the AUTO position to allow startup by the automatic transfer switch or the remote start/stop switch (connected to controller terminals TB1-3 and TB1-4).

Note: The controller provides up to 30 seconds of continuous cranking before overcrank shutdown occurs.

x:op:002:003

2.8.3 Stopping the Generator Set

The following procedure describe how to stop the generator set.

Normal Stopping

1. **Cooldown.** Run the generator set at no load for 5 minutes to ensure adequate engine cooldown.

2. **Stopping.** Move the generator set master switch to the OFF/RESET position. The engine stops.

x:op:002:004

2.8.4 Fault Shutdowns

The generator set shuts down automatically under the following fault conditions and cannot be restarted until the fault condition is corrected. The system automatically resets when the problem is corrected or the generator set cools (if high engine temperature was the fault).

The fault lamp does not stay lit after the generator set shuts down on a fault condition.

2.8.5 Controller Resetting Procedure (Following Fault Shutdown)

Use the following procedure to restart the generator set after a fault shutdown.

1. Disconnect the generator set from the load using the line circuit breaker or automatic transfer switch. See the Safety Precautions at the beginning of this section before proceeding.

2. Correct the cause of the fault shutdown. See the Safety Precautions at the beginning of this section before proceeding.

3. Start the generator set by moving the generator set master switch to RESET/OFF and then to RUN.

4. Verify that the cause of the shutdown has been corrected by test operating the generator set.

5. Reconnect the generator set to the load using the line circuit breaker or automatic transfer switch.

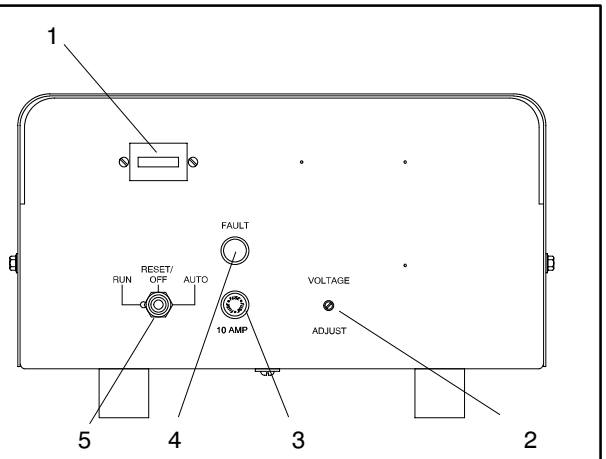
6. Move the generator set master switch to the AUTO position for startup by remote transfer switch or remote start/stop switch.

Fault	Description
High engine temperature	Shutdown occurs 5 seconds after the fault. The high engine temperature shutdown does not function during the first 5 seconds after startup. **Note:** The high temperature shutdown functions only when the coolant level is in the operating range.
High exhaust temperature	Shutdown occurs 5 seconds after the fault. The high exhaust temperature shutdown does not function during the first 5 seconds after startup.
Low coolant level	Shutdown occurs 5 seconds after the fault. The low coolant level shutdown does not function during the first 5 seconds after startup.
Low oil pressure	Shutdown occurs 5 seconds after the fault. The low oil pressure shutdown does not function during the first 5 seconds after startup. **Note:** The low oil pressure shutdown does not protect against low oil level. Check the oil level at the engine.
Overcrank	Shutdown occurs after 30 seconds of continuous cranking. Shutdown occurs after 30 seconds if the engine or starter does not turn (locked rotor).
Overspeed	Shutdown occurs immediately when the governed frequency on the 50 and 60 Hz models exceeds 70 Hz.

x:op:002:006

2.9 Standard Decision-Maker™ 1 Controller Operation

For identification of the standard basic controller's indicators and controls and their functions, refer to Figure 2-6.



1. Hourmeter
2. Voltage adjustment
3. 10-amp controller fuse
4. Fault lamp
5. Generator set master switch

Figure 2-6 Decision-Maker™ 1 Controller

x:op:004:001

2.9.1 Controls and Indicators

The following table describes the controls and indicators located on the controller.

Name	Description
Fault lamp	Lamp illuminates during engine shutdown if the engine shuts down because of one of the following faults: high engine temperature, low water level, low oil pressure, overcrank, or overspeed. See Section 2.9.4, Fault Shutdowns, for additional shutdown information.
Generator set master switch	Switch functions as the controller reset and generator operation switch.
Hourmeter	Hourmeter records the generator set total operating hours for reference in maintenance scheduling.
Voltage adjust potentiometer	Potentiometer fine-tunes (±5%) generator output voltage.
10-amp controller fuse	Fuse protects the controller circuitry from short circuits and overloads.

x:op:004:002

2.9.2 Starting the Generator Set

The following procedures describe the actions required to start the generator set.

Local Starting. Move the generator set master switch to the RUN position to immediately start the generator set.

Automatic (Auto) Starting. Move the generator set master switch to the AUTO position to allow startup by the automatic transfer switch or the remote start/stop switch (connected to controller terminals TB1-3 and TB1-4).

Note: The controller provides up to 30 seconds of continuous cranking before the overcrank shutdown occurs.

x:op:004:003

2.9.3 Stopping the Generator Set

The following procedure describe how to stop the generator set.

Normal Stopping

1. **Cooldown**. Run the generator set at no load for 5 minutes to ensure adequate engine cooldown.
2. **Stopping**. Move the generator set master switch to the OFF/RESET position. The engine stops.

x:op:004:004

2.9.4 Fault Shutdowns

The generator set shuts down automatically under the following fault conditions and cannot be restarted until the fault condition is corrected. The system automatically resets when the problem is corrected or the generator set cools (if high engine temperature was the fault).

Fault	Description
High engine temperature	Shutdown occurs 5 seconds after the fault. The high engine temperature shutdown does not function during the first 5 seconds after startup. **NOTE:** The high temperature shutdown functions only when the coolant level is in the operating range.
High exhaust temperature	Shutdown occurs 5 seconds after the fault. The high exhaust temperature shutdown does not function during the first 5 seconds after startup.
Low coolant level	Shutdown occurs 5 seconds after the fault. Low coolant level shutdown does not function during the first 5 seconds after startup.
Low oil pressure	Shutdown occurs 5 seconds after the fault. Low oil pressure shutdown does not function during the first 5 seconds after startup. **NOTE:** The low oil pressure shutdown does not protect against low oil level. Check the oil level at the engine.
Overcrank	Shutdown occurs after 30 seconds of continuous cranking. Shutdown occurs after 30 seconds if the engine or starter does not turn (locked rotor).
Overspeed	Shutdown occurs immediately when the governed frequency on 50 and 60 Hz models exceeds 70 Hz.

x:op:004:005

2.9.5 Controller Resetting Procedure (Following Fault Shutdown)

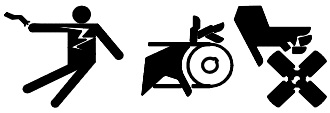
Use the following procedure to restart the generator set after a fault shutdown.

1. Disconnect the generator set from the load using the line circuit breaker or automatic transfer switch. See the Safety Precautions at the beginning of this section before proceeding.
2. Correct the cause of the fault shutdown. See the Safety Precautions at the beginning of this section before proceeding.
3. Start the generator set by moving the generator set master switch to RESET/OFF and then to RUN.
4. Verify that the cause of the shutdown has been corrected by test operating the generator set.
5. Reconnect the generator set to the load using the line circuit breaker or automatic transfer switch.
6. Move the generator set master switch to the AUTO position for startup by remote transfer switch or remote start/stop switch.

x:op:004:006

3.1 General Maintenance

⚠ WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

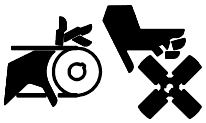
⚠ WARNING

Hot engine and exhaust system.
Can cause severe injury or death.

Do not work on the generator set until it cools.

Servicing the exhaust system. Hot parts can cause severe injury or death. Do not touch hot engine parts. The engine and exhaust system components become extremely hot during operation.

⚠ WARNING



Rotating parts.
Can cause severe injury or death.

Operate the generator set only when all guards, screens, and covers are in place.

Servicing the generator set when it is operating. Exposed moving parts can cause severe injury or death. Keep hands, feet, hair, clothing, and test leads away from the belts and pulleys when the generator set is running. Replace guards, screens, and covers before operating the generator set.

See the Safety Precautions and Instructions at the beginning of this manual before attempting to service, repair, or operate the generator set. Have an authorized distributor/dealer perform generator set service.

Engine Service. Perform generator set engine service at the intervals specified by the engine operation manual.

Generator Set Service. Perform generator set service at the intervals specified by the generator set operation manual.

If the generator set operates under dusty or dirty conditions, use *dry* compressed air to blow dust out of the alternator. With the generator set running, direct the stream of air in through the cooling slots at the alternator end.

Service Log. Use the Operating Hour Service Log located in the back of this manual to document performed services.

Service Schedule. Perform maintenance on each item in the service schedule at the designated intervals for the life of the generator set. For example, an item requiring service every 100 hours or 3 months also requires service after 200 hours or 6 months, 300 hours or 9 months, and so on.

x:sm:004:001

3.2 Generator Bearing

Replace the end bracket bearing every 10,000 hours of operation. Service more frequently if bearing inspection indicates excessive rotor end play or bearing damage from corrosion or heat buildup. Replace the tolerance ring, if equipped, if removing the end bracket. The end bracket bearing is sealed and requires no additional lubrication. Have all generator service performed by an authorized service distributor/dealer.

3.3 Storage Procedure

Perform the following storage procedure before taking a generator set out of service for three months or longer. Follow the engine manufacturer's recommendations, if available, for fuel system and internal engine component storage.

x:sm:002:001

3.3.1 Lubricating System

Prepare the engine lubricating system for storage as follows:

1. Run the generator set for a minimum of 30 minutes to bring it to normal operating temperature.
2. Stop the generator set.
3. With the engine still warm, drain the oil from the crankcase.
4. Remove and replace the oil filter.
5. Refill the crankcase with oil suited to the climate.
6. Run the generator set for two minutes to distribute the clean oil.
7. Stop the generator set.
8. Check the oil level and adjust, if needed.

x:sm:002:002

3.3.2 Cooling System

Prepare the cooling system for storage as follows:

1. Check the coolant freeze protection using a coolant tester.
2. Add or replace coolant as necessary to ensure adequate freezing protection. Use the guidelines included in the engine operation manual.
3. Run the generator set for 30 minutes to redistribute added coolant.

x:sm:002:003

3.3.3 Fuel System

Prepare the fuel system for storage as follows:

Diesel-Fueled Engines

1. Fill the fuel tank with #2 diesel fuel.
2. Condition the fuel system with compatible additives to control microbial growth.
3. Change the fuel filter/separator and bleed the fuel system. See the engine service manual.

3.3.4 Exterior

Prepare the exterior for storage as follows:

1. Clean the exterior surface of the generator set.
2. Seal all engine openings except for the air intake with nonabsorbent adhesive tape.
3. To prevent impurities from entering the air intake and to allow moisture to escape from the engine, secure a cloth over the air intake.
4. Mask electrical connections.
5. Spread a light film of oil over unpainted metallic surfaces to inhibit rust and corrosion.

x:sm:002:006a

3.3.5 Battery

Perform battery storage after all other storage procedures.

1. Place the generator set master switch in the OFF/RESET position.
2. Disconnect the battery(ies), negative (-) lead first.
3. Clean the battery. Refer to the battery manufacturer's instructions for the battery cleaning procedure.
4. Place the battery in a cool, dry location.
5. Connect the battery to a float/equalize battery charger or charge it monthly with a trickle battery charger. Refer to the battery charger manufacturer's recommendations.
6. Maintain a full charge to extend battery life.

Section 4 General Troubleshooting

This section contains generator set troubleshooting, diagnostic, and repair information.

Use the following chart as a quick troubleshooting reference. The table groups generator set faults and suggests likely causes and remedies. The table also refers you to more detailed information including sections of this manual, the generator set operation manual (O/M), the generator set installation manual (I/M), and the engine service manual (Engine S/M) to correct the indicated problem.

Corrective action and testing often require knowledge of electrical and electronic circuits. To avoid additional problems caused by incorrect repairs, have an authorized service distributor/dealer perform service.

NOTICE

Fuse replacement. Replace fuses with fuses of the same ampere rating and type (for example: 3AB or 314, ceramic). Do not substitute clear glass-type fuses for ceramic fuses. Refer to the wiring diagram when the ampere rating is unknown or questionable.

Maintain a record of repairs and adjustments performed on the equipment. If the procedures in this manual do not explain how to correct the problem, contact an authorized distributor/dealer. Use the record to help describe the problem and repairs or adjustments made to the equipment.

x:gt:001:002a:

Trouble Symptoms										Probable Causes	Recommended Actions	Section or Publication Reference*
Does not crank	Cranks but does not start	Starts hard	No or low output voltage	Stops suddenly	Lacks power	Overheats	Low oil pressure	High fuel consumption	Excessive or abnormal noise			
Controller												
x										Controller master switch in the OFF/RESET position	Move the controller master switch to the RUN or AUTO position.	Section 2
x	x			x						Controller fuse blown	Replace the blown controller fuse. If the fuse blows again, troubleshoot the controller.†	Section 2, W/D
x				x						Controller circuit breaker tripped	Reset the controller circuit breaker.	Section 2
x										Controller master or start/stop switch inoperative	Replace the controller master or start/stop switch.	—
				x						Controller fault	Troubleshoot the controller.†	Section 5 or 6
x	x									Controller circuit board(s) inoperative	Replace the controller circuit board.	Section 5 or 6
Cooling System												
						x		x		Air openings clogged	Clean the air openings.	—
						x				Impeller inoperative	Replace the impeller	Gen. O/M
						x		x		Seawater strainer clogged or restricted	Clean the strainer.	Gen. O/M
				x						High temperature shutdown	Allow the engine to cool down. Then troubleshoot the cooling system.	Eng. O/M
				x						Low coolant level shutdown, if equipped	Restore the coolant to normal operating level.	Gen. O/M
						x				Coolant level low	Restore the coolant to normal operating level.	Gen. O/M
						x				Thermostat inoperative	Replace the thermostat.	Eng. S/M
						x				Cooling water pump inoperative	Tighten or replace the belt. Replace the water pump.	Eng. O/M or S/M

* Sec./Section—numbered section of this manual; ATS—Automatic Transfer Switch; Eng.—Engine; Gen.—Generator Set; I/M—Installation Manual; O/M—Operation Manual; S/M—Service Manual; S/S—Spec Sheet; W/D—Wiring Diagram Manual

† Have an authorized service distributor/dealer perform this service.

Trouble Symptoms										Probable Causes	Recommended Actions	Section or Publication Reference*
Does not crank	Cranks but does not start	Starts hard	No or low output voltage	Stops suddenly	Lacks power	Overheats	Low oil pressure	High fuel consumption	Excessive or abnormal noise			
Electrical System (DC circuits)												
x	x									Battery connections loose, corroded, or incorrect	Verify that the battery connections are correct, clean, and tight.	Eng. O/M
x	x									Battery weak or dead	Recharge or replace the battery. The spec sheet provides recommended battery CCA rating.	S/S
x				x						Engine harness connector(s) not locked tight	Disconnect the engine harness connector(s) then reconnect it to the controller.	W/D
				x						Fault shutdown	Reset the fault switches and troubleshoot the controller.	Section 2
				x						High exhaust temperature switch inoperative	Replace the inoperative switch.	Gen. S/M or W/D
x	x									Starter/starter solenoid inoperative	Replace the starter or starter solenoid.	Eng. S/M
				x						High water temperature switch inoperative	Replace the inoperative switch.	Gen. S/M
Engine												
	x	x			x			x		Air cleaner clogged	Clean or replace the filter element.	Gen. O/M
	x	x				x		x	x	Compression weak	Check the compression.†	Eng. S/M
			x		x	x		x	x	Engine overload	Reduce the electrical load. See the generator set spec sheet for wattage specifications.	S/S
									x	Exhaust system leak	Inspect the exhaust system. Replace the inoperative exhaust system components.†	I/M
									x	Exhaust system not securely installed	Inspect the exhaust system. Tighten the loose exhaust system components.†	I/M
		x	x		x			x		Governor inoperative	Adjust the governor.†	Section 7
					x				x	Valve clearance incorrect	Adjust the valves.†	Eng. S/M
									x	Vibration excessive	Tighten all loose hardware.	—

* Sec./Section—numbered section of this manual; ATS—Automatic Transfer Switch; Eng.—Engine; Gen.—Generator Set; I/M—Installation Manual; O/M—Operation Manual; S/M—Service Manual; S/S—Spec Sheet; W/D—Wiring Diagram Manual

† Have an authorized service distributor/dealer perform this service.

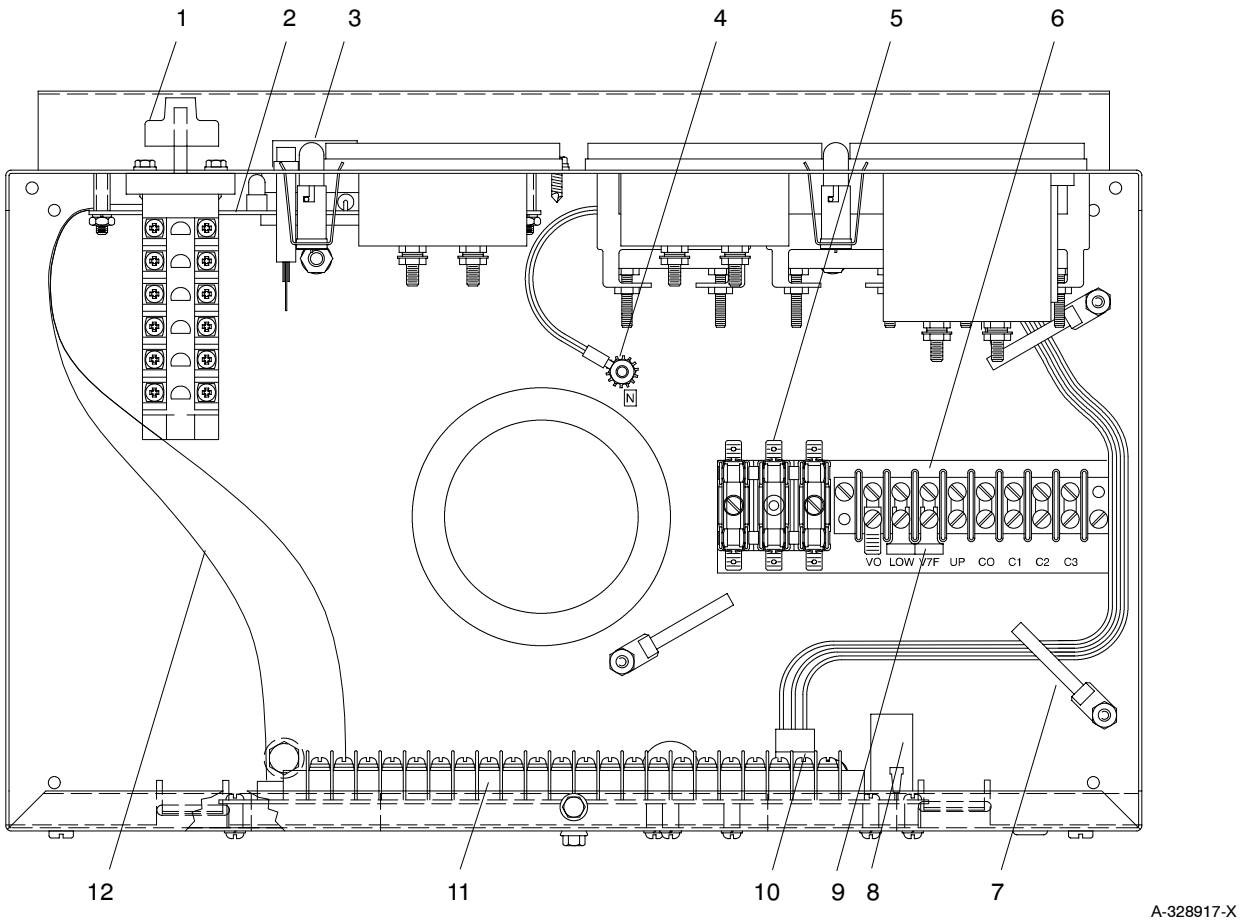
Trouble Symptoms										Probable Causes	Recommended Actions	Section or Publication Reference*
Does not crank	Cranks but does not start	Starts hard	No or low output voltage	Stops suddenly	Lacks power	Overheats	Low oil pressure	High fuel consumption	Excessive or abnormal noise			
Fuel System												
	x			x						Fuel tank empty or fuel valve shut off	Add fuel and move the fuel valve to the ON position.	—
	x	x		x	x					Fuel filter restriction	Clean or replace the fuel filter.	Eng. O/M
	x									Fuel solenoid inoperative	Troubleshoot the fuel solenoid.†	Eng. S/M
	x	x			x					Air in fuel system (diesel only)	Bleed the diesel fuel system.	Eng. O/M
	x	x			x					Fuel or fuel injectors dirty or faulty (diesel only)	Clean, test, and/or replace the inoperative fuel injector.†	Eng. S/M
	x	x			x			x		Fuel injection timing out of adjustment (diesel only)	Adjust the fuel injection timing.†	Eng. S/M
	x				x			x		Fuel feed or injection pump inoperative (diesel only)	Rebuild or replace the injection pump.†	Eng. S/M
Generator												
			x							AC output circuit breaker open	Reset the breaker and check for AC voltage at the generator side of the circuit breaker.	—
x										Transfer switch test switch in the OFF position	Move the transfer switch test switch to the AUTO position.	ATS O/M
			x							Wiring, terminals, or pin in the exciter field open	Check for continuity.	Section 7, W/D
			x							Main field (rotor) inoperative (open or grounded)	Test and/or replace the rotor.†	Section 7
			x							Stator inoperative (open or grounded)	Test and/or replace the stator.†	Section 7
									x	Vibration excessive	Tighten loose components.†	—
			x	x						Voltage regulator out of adjustment	Adjust the voltage regulator.	Section 7
			x	x						Voltage regulator inoperative	Replace the voltage regulator fuse, If the fuse blows again, troubleshoot the voltage regulator.	Section 7
Lube System												
						x	x		x	Oil level low	Restore the oil level. Inspect the generator set for oil leaks.	Eng. O/M
				x						Low oil pressure shutdown	Check the oil level.	Eng. O/M
	x	x					x		x	Crankcase oil type incorrect for ambient temperature	Change the oil. Use oil with a viscosity suitable for the operating climate.	Eng. O/M

* Sec./Section—numbered section of this manual; ATS—Automatic Transfer Switch; Eng.—Engine; Gen.—Generator Set; I/M—Installation Manual; O/M—Operation Manual; S/M—Service Manual; S/S—Spec Sheet; W/D—Wiring Diagram Manual

† Have an authorized service distributor/dealer perform this service.

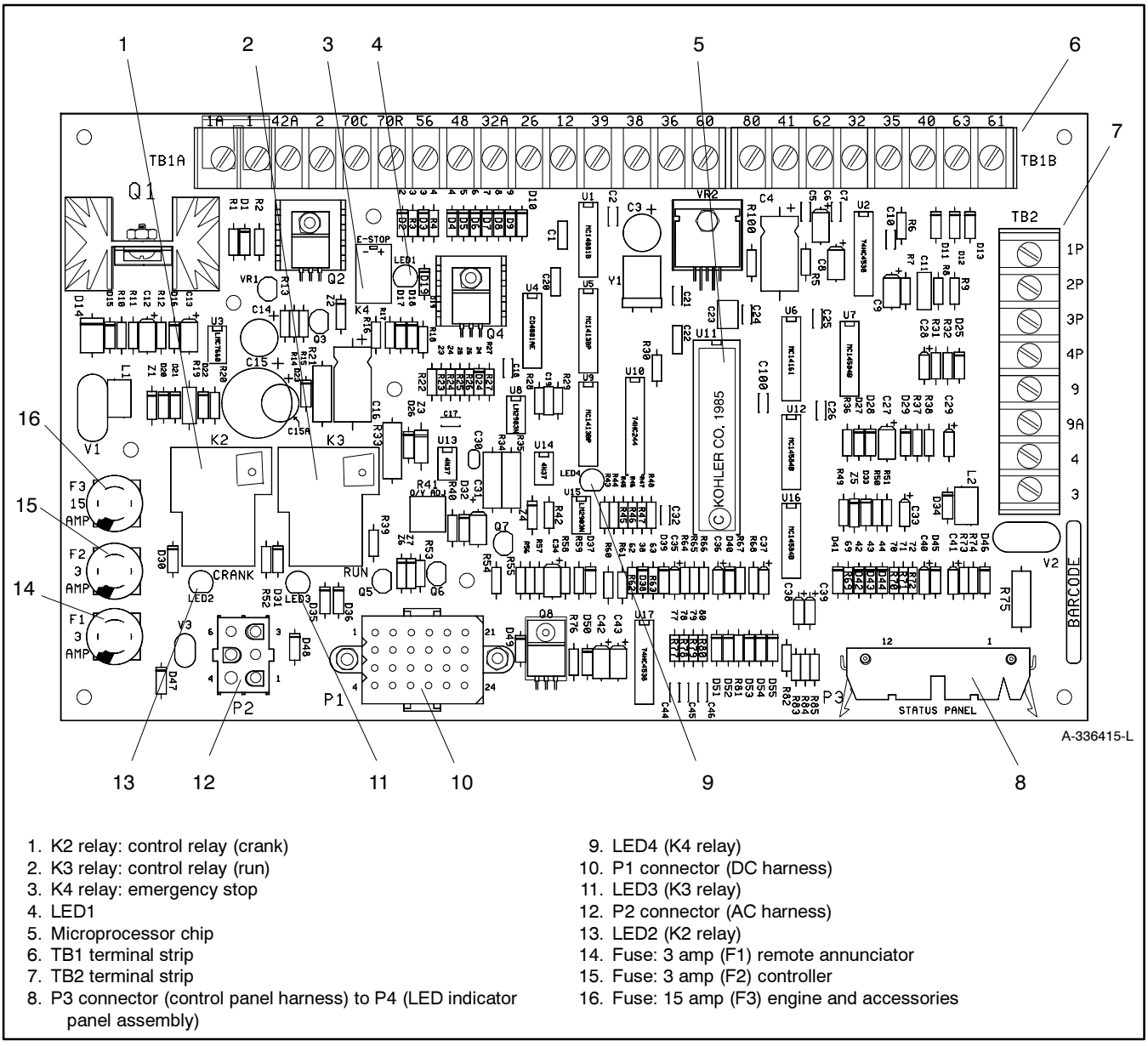
5.1 Decision-Maker™ 3+ Controller

For external features, see Section 2, Operation. Figure 5-1 through Figure 5-11 show the locations of controller components and connections. Figure 5-12 contains the logic schematic showing input/output circuits for reference in troubleshooting. This information deals directly with the 16-light microprocessor.



1. Selector switch
2. Lamp circuit board
3. Panel lamps
4. Controller DC ground terminal
5. AC fuse terminal block (TB3)
6. CT/meter scale terminal block (TB2)
7. Accessory wire guide loops
8. Controller fuses
9. Lamp selection jumper
10. Control panel harness connector (P2)
11. Controller main circuit board
12. P3/P4 harness

Figure 5-1 Decision-Maker™ 3+ Controller



1. K2 relay: control relay (crank)
2. K3 relay: control relay (run)
3. K4 relay: emergency stop
4. LED1
5. Microprocessor chip
6. TB1 terminal strip
7. TB2 terminal strip
8. P3 connector (control panel harness) to P4 (LED indicator panel assembly)
9. LED4 (K4 relay)
10. P1 connector (DC harness)
11. LED3 (K3 relay)
12. P2 connector (AC harness)
13. LED2 (K2 relay)
14. Fuse: 3 amp (F1) remote annunciator
15. Fuse: 3 amp (F2) controller
16. Fuse: 15 amp (F3) engine and accessories

Figure 5-2 Decision-Maker™ 3+ Controller Circuit Board Components, Typical

5.1.1 Decision-Maker 3+ Circuit Board Terminal/Connector Identification

Terminal	Wire	Description
1	1A	Emergency stop relay (K4) coil
2	1	Ground—emergency stop relay (K4)
3	42A	Battery voltage (fuse #1 protected)
4	2	Ground
5	70C	Generator in cool-down mode signal
6	70R	Generator in running mode signal
7	56	Air damper indicator, if equipped
8	48	Emergency stop indicator
9	32A	Common fault/prealarm
10	26	Auxiliary indicator
11	12	Overcrank indicator
12	39	Overspeed indicator
13	38	Low oil pressure indicator
14	36	High engine temperature indicator
15	60	System ready indicator
16	80	Not-in-auto indicator
17	41	Prealarm low oil pressure indicator
18	62	Low battery volts (active low*)
19	32	Common fault/prealarm
20	35	Low water temperature
21	40	Prealarm high engine temperature indicator
22	63	Low fuel (active low*)
23	61	Battery charger fault (active low*)

* Check the operation of active low circuits by placing ground on terminals so designated.

Figure 5-3 Terminal Strip TB1

Terminal	Wire	Description
1	1P	Prime power operation (requires optional kit)
2	2P	Prime power operation (requires optional kit)
3	3P	Prime power operation (requires optional kit)
4	4P	Prime power operation (requires optional kit)
5	9	Crank mode (open-cyclic ground continuous)
6	9A	Crank mode ground
7	4	Remote start (active low*)
8	3	Remote start (ground)

* Check the operation of active low circuits by placing ground on terminals so designated.

Figure 5-4 Terminal Strip TB2

Pin	Description
1	Output to K1 relay (crank relay), wire 71
2	Ground for speed sensor, wire 2
3	Output to safeguard breaker terminal, wire 70 (and K5 relay if equipped with electronic governor)
4	Not used
5	Ground (–), wire N
6	Speed sensor shield ground, wire S2
7	Output to fuel solenoid (FS), wire 70
8	Battery positive to speed sensor, wire 24
9	Input from speed sensor, wire 16
10	Not used
11	Not used
12	Input from battery positive (14P)
13	Not used
14	Input from high exhaust temperature switch, wire 31
15	Not used
16	Input from pre-high engine temperature switch, wire 40A
17	Input from aux. immediate shutdown
18	Not used
19	Not used
20	Not used
21	Input from high engine temperature switch, wire 34
22	Input from low oil pressure switch, wire 13
23	Input from pre-low oil pressure switch, wire 41A
24	Not used

* Check the operation of active low circuits by placing ground on terminals so designated.

Figure 5-5 P1 Connector Pins

Pin	Description
1	Output to engine gauge, wire 70
2	Not used
3	Input for AC crank disconnect & instrumentation, wire V7F
4	Not used
5	Input for AC crank disconnect & instrumentation, wire V0
6	Engine ground, wire 2

Figure 5-6 P2 Connector Pins

Pin	Description
1	Ground (–), front panel, wire 2
2	Not used
3	Not used
4	Input from generator set master switch, auto position, wire 46
5	Not used
6	Voltage (+) to front panel, wire 24
7	Output to low oil pressure indicator, wire 38
8	Output to overspeed indicator, wire 39
9	Output to overcrank indicator, wire 12
10	Output to auxiliary indicator, wire 26
11	Output to emergency stop lamp, wire 48
12	Output to pre-high engine temperature indicator, wire 40
13	Output to high engine temperature indicator, wire 36
14	Output to system ready indicator, wire 60
15	Output to not-in-auto indicator, wire 80
16	Output to low water temperature indicator, wire 35
17	Output to pre-low oil pressure indicator, wire 41
18	Output to air damper indicator, if equipped, wire 56
19	Output to low battery volts indicator, wire 62
20	Output to battery charger fault indicator, wire 61
21	Output to low fuel indicator, wire 63
22	Output to common alarm, wire 32
23	Input from generator master switch, off/reset position, wire 43
24	Input from generator set master switch, run position, wire 47

Figure 5-7 P3 Connector Pins

Pin	Description
1	Ground (–), front panel, wire 2
2	Not used
3	Not used
4	Output from generator set master switch, auto position, wire 46
5	Not used
6	Voltage (+) to front panel, wire 24
7	Input to low oil pressure indicator, wire 38†
8	Input to overspeed indicator, wire 39†
9	Input to overcrank indicator, wire 12†
10	Input to auxiliary indicator, wire 26
11	Input to emergency stop lamp, wire 48
12	Input to pre-high engine temperature indicator, wire 40†
13	Input to high engine temperature indicator, wire 36†
14	Input to system ready indicator, wire 60
15	Input to not-in-auto indicator, wire 80
16	Input to low water temperature indicator, wire 35†
17	Input to pre-low oil pressure indicator, wire 41†
18	Input to air damper indicator, if equipped, wire 56
19	Input to low battery volts indicator, wire 62
20	Input to battery charger fault indicator, wire 61
21	Input to low fuel indicator, wire 63†
22	Input to common alarm, wire 32†
23	Output from generator master switch, off/reset position, wire 43
24	Output from generator set master switch, run position, wire 47

† Common alarm triggered by high engine temp., high engine temp. prealarm, low oil pressure, low oil pressure prealarm, low water temp., overcrank, overspeed, low fuel, and auxiliary faults.

Figure 5-8 P4 Connector Pins

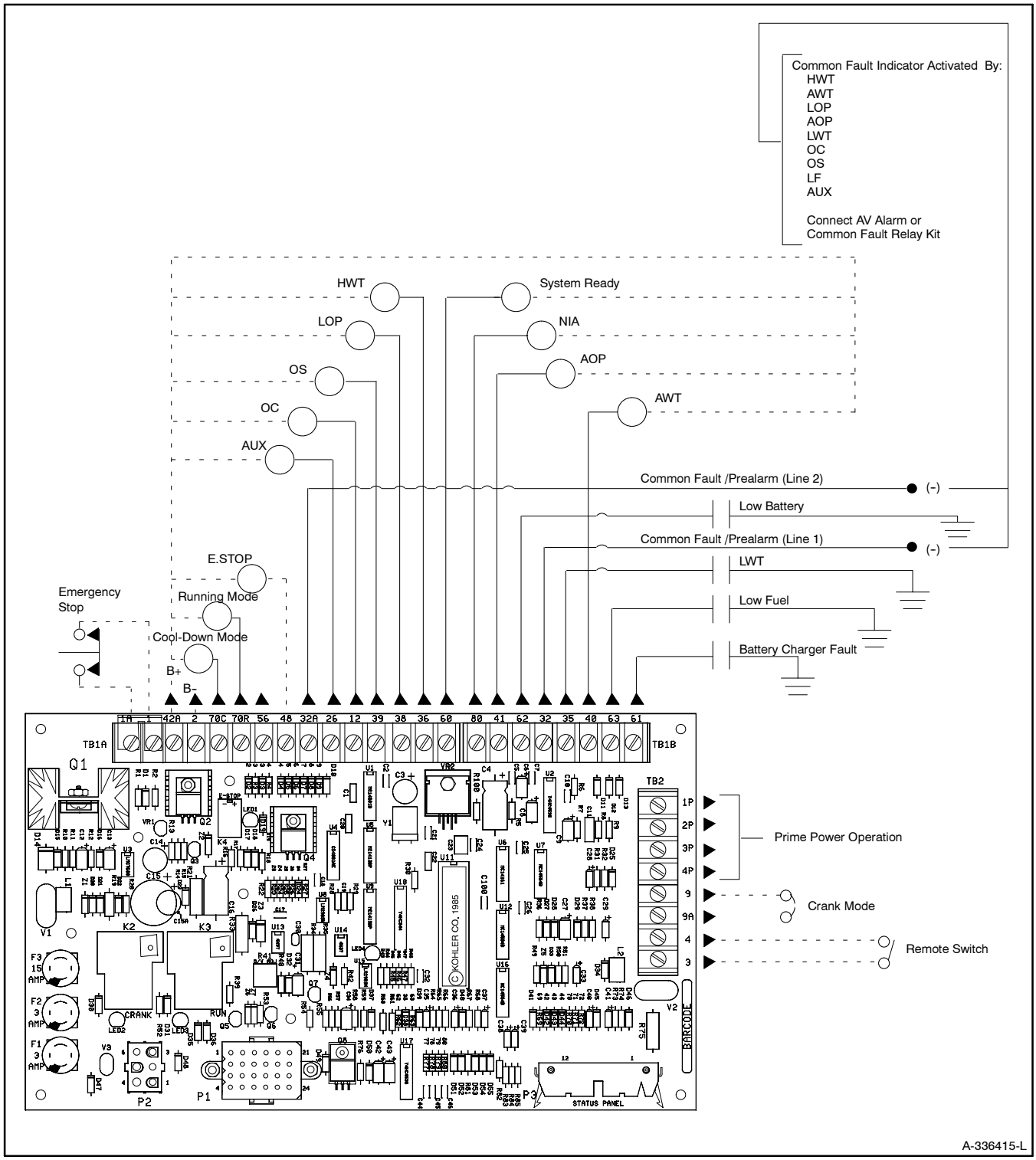


Figure 5-9 Decision-Maker™ 3+ Controller Connections (TB1 and TB2 terminal strips)

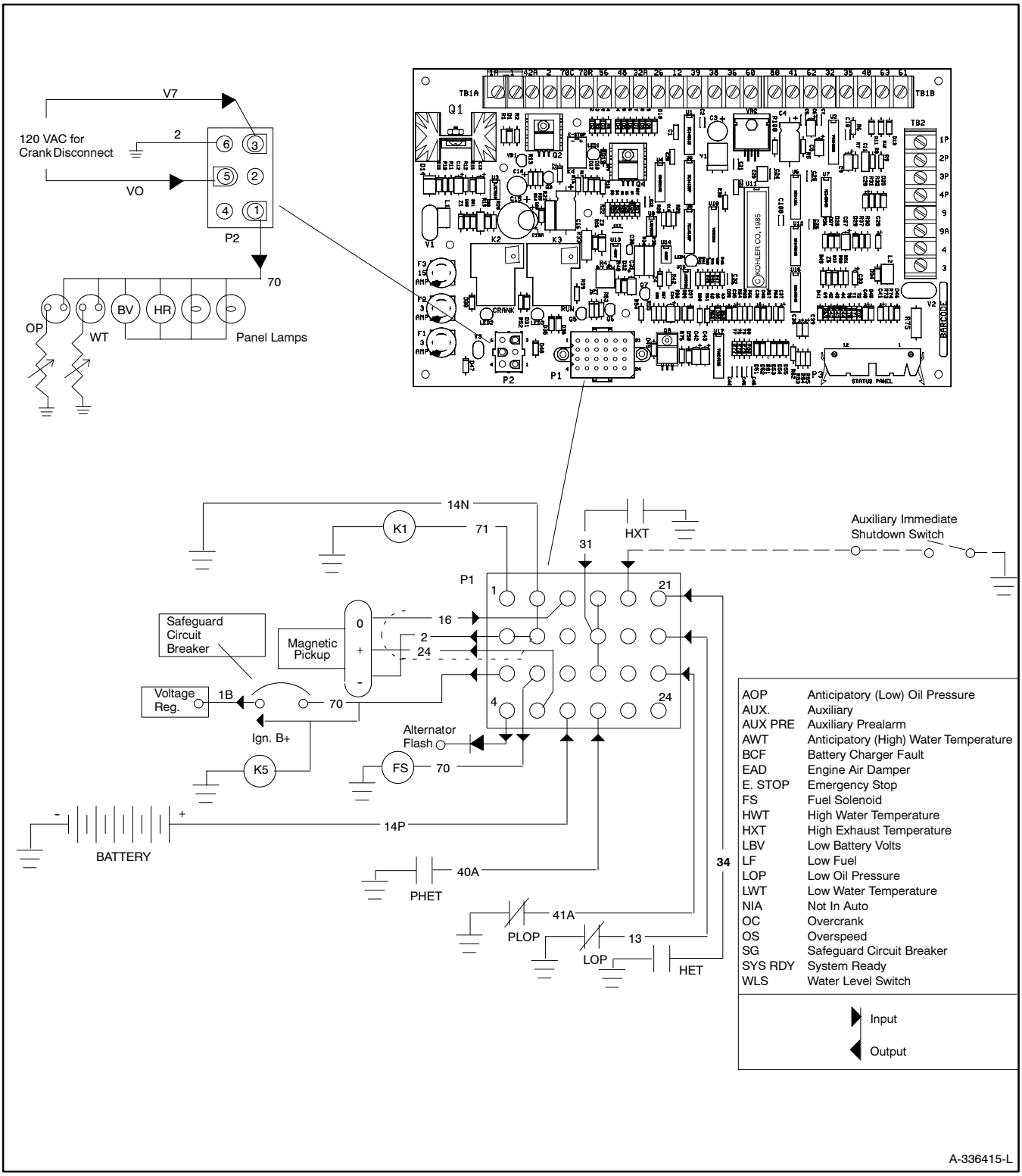


Figure 5-10 Decision-Maker™ 3+ Controller Connections (P1 and P2)

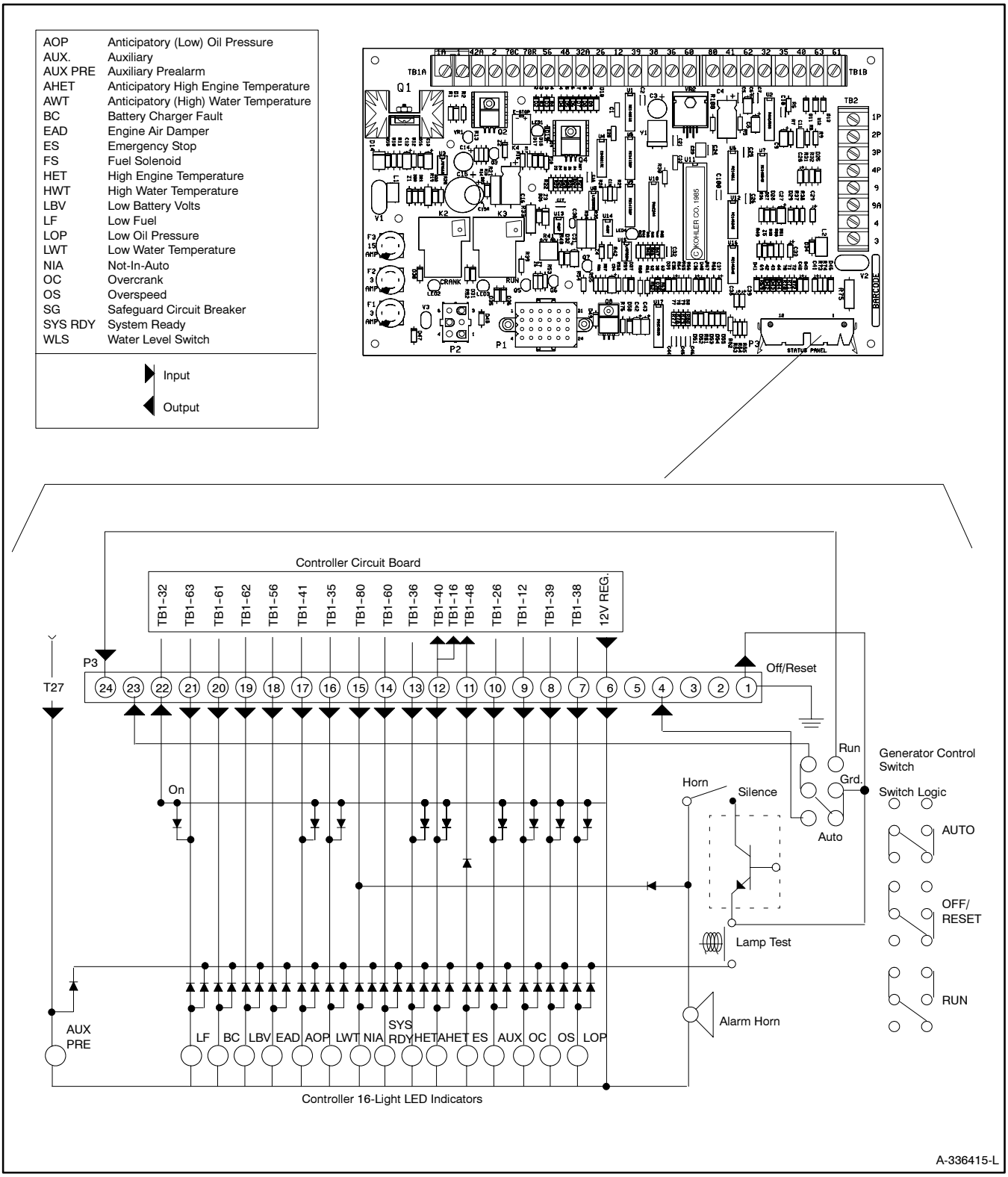


Figure 5-11 Decision-Maker™ 3+ to 16-Light LED Indicator Panel Connections (P3)

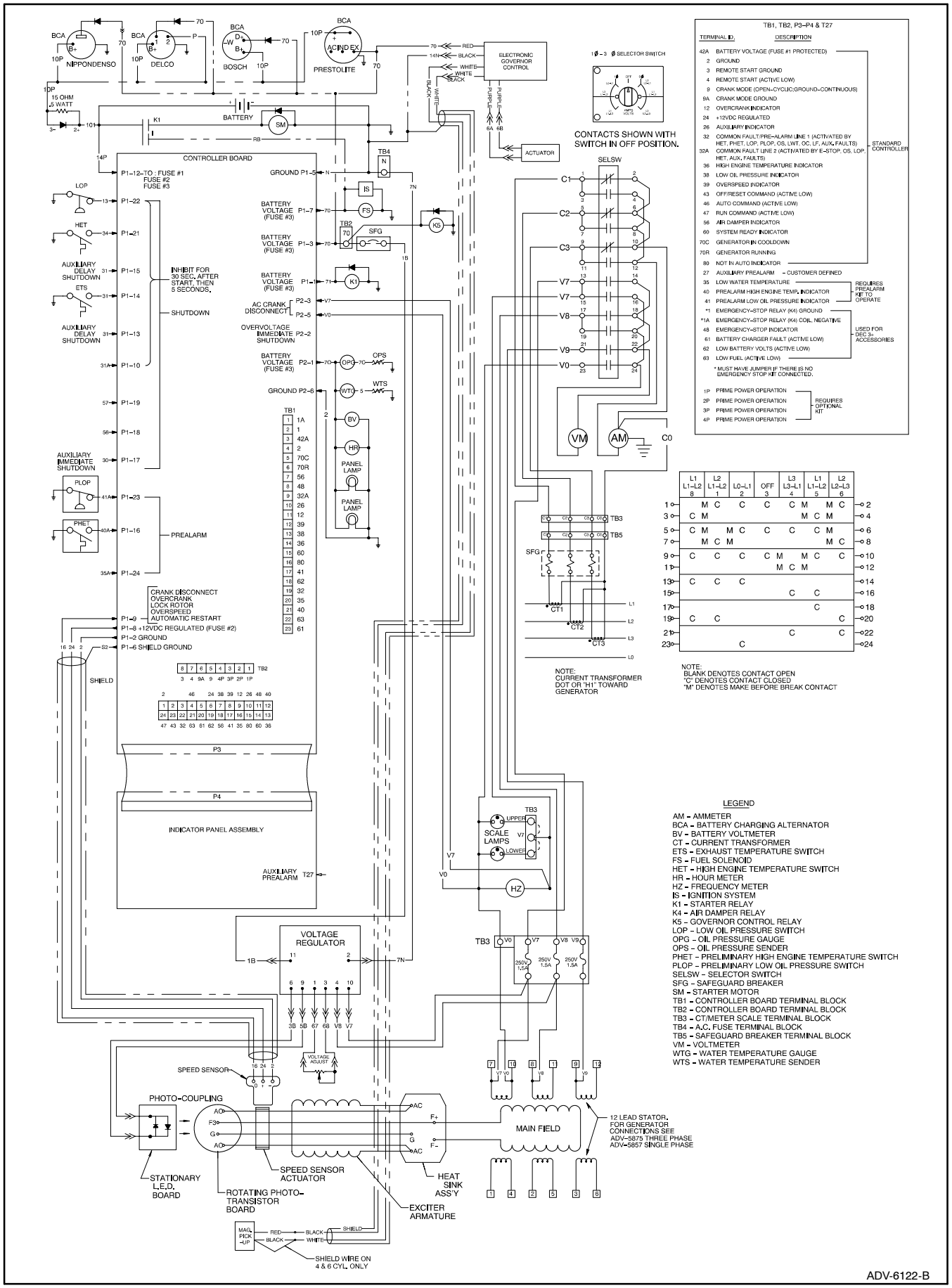

TB1, TB2, P3–P4 & T27
TERMINAL ID.
DESCRIPTION
42A BATTERY VOLTAGE (FUSE #1 PROTECTED)
2 GROUND
3 REMOTE START GROUND
4 REMOTE START (ACTIVE LOW)
9 CRANK MODE (OPEN–CYCLIC;GROUND–CONTINUOUS)
9A CRANK MODE GROUND
12 OVERCRANK INDICATOR
24 +12VDC REGULATED
26 AUXILIARY INDICATOR
32 COMMON FAULT/PRE–ALARM LINE 1 (ACTIVATED BY HET, PHET, LOP, PLOP, OS, LWT, OC, LF, AUX, FAULTS)
32A COMMON FAULT LINE 2 (ACTIVATED BY E–STOP, OS, LOP, HET, AUX, FAULTS)
36 HIGH ENGINE TEMPERATURE INDICATOR
38 LOW OIL PRESSURE INDICATOR
39 OVERSPEED INDICATOR
43 OFF/RESET COMMAND (ACTIVE LOW)
46 AUTO COMMAND (ACTIVE LOW)
47 RUN COMMAND (ACTIVE LOW)
56 AIR DAMPER INDICATOR
60 SYSTEM READY INDICATOR
70C GENERATOR IN COOLDOWN
70R GENERATOR RUNNING
80 NOT IN AUTO INDICATOR
27 AUXILIARY PREALARM – CUSTOMER DEFINED
35 LOW WATER TEMPERATURE
40 PREALARM HIGH ENGINE TEMP. INDICATOR
41 PREALARM LOW OIL PRESSURE INDICATOR
*1 EMERGENCY–STOP RELAY (K4) GROUND
*1A EMERGENCY–STOP RELAY (K4) COIL NEGATIVE
48 EMERGENCY–STOP INDICATOR
61 BATTERY CHARGER FAULT (ACTIVE LOW)
62 LOW BATTERY VOLTS (ACTIVE LOW)
63 LOW FUEL (ACTIVE LOW)
* MUST HAVE JUMPER IF THERE IS NO EMERGENCY STOP KIT CONNECTED.
STANDARD CONTROLLER
REQUIRES PREALARM KIT TO OPERATE
USED FOR DEC 3+ ACCESSORIES
1P PRIME POWER OPERATION
2P PRIME POWER OPERATION
3P PRIME POWER OPERATION
4P PRIME POWER OPERATION
REQUIRES OPTIONAL KIT
CONTACTS SHOWN WITH SWITCH IN OFF POSITION.
1Ø – 3 Ø SELECTOR SWITCH
SELSW
NOTE: CURRENT TRANSFORMER DOT OR "H1" TOWARD GENERATOR
NOTE: BLANK DENOTES CONTACT OPEN "C" DENOTES CONTACT CLOSED "M" DENOTES MAKE BEFORE BREAK CONTACT
LEGEND
AM – AMMETER
BCA – BATTERY CHARGING ALTERNATOR
BV – BATTERY VOLTMETER
CT – CURRENT TRANSFORMER
ETS – EXHAUST TEMPERATURE SWITCH
FS – FUEL SOLENOID
HET – HIGH ENGINE TEMPERATURE SWITCH
HR – HOUR METER
HZ – FREQUENCY METER
IS – IGNITION SYSTEM
K1 – STARTER RELAY
K4 – AIR DAMPER RELAY
K5 – GOVERNOR CONTROL RELAY
LOP – LOW OIL PRESSURE SWITCH
OPG – OIL PRESSURE GAUGE
OPS – OIL PRESSURE SENDER
PHET – PRELIMINARY HIGH ENGINE TEMPERATURE SWITCH
PLOP – PRELIMINARY LOW OIL PRESSURE SWITCH
SELSW – SELECTOR SWITCH
SFG – SAFEGUARD BREAKER
SM – STARTER MOTOR
TB1 – CONTROLLER BOARD TERMINAL BLOCK
TB2 – CONTROLLER BOARD TERMINAL BLOCK
TB3 – CT/METER SCALE TERMINAL BLOCK
TB4 – A.C. FUSE TERMINAL BLOCK
TB5 – SAFEGUARD BREAKER TERMINAL BLOCK
VM – VOLTMETER
WTG – WATER TEMPERATURE GAUGE
WTS – WATER TEMPERATURE SENDER
CONTROLLER BOARD
INDICATOR PANEL ASSEMBLY
ELECTRONIC GOVERNOR CONTROL
ACTUATOR
BATTERY
NIPPONDENSO
DELCO
BOSCH
PRESTOLITE
ACIND EX
15 OHM 5 WATT
SHUTDOWN
PREALARM
INHIBIT FOR 30 SEC. AFTER START, THEN 5 SECONDS.
CRANK DISCONNECT
OVERCRANK
LOCK ROTOR
OVERSPEED
AUTOMATIC RESTART
P1–8 +12VDC REGULATED (FUSE #2)
P1–2 GROUND
P1–6 SHIELD GROUND
SHIELD
VOLTAGE REGULATOR
VOLTAGE ADJUST
SPEED SENSOR
PHOTO–COUPLING
STATIONARY L.E.D. BOARD
ROTATING PHOTO–TRANSISTOR BOARD
SPEED SENSOR ACTUATOR
HEAT SINK ASS'Y
EXCITER ARMATURE
MAIN FIELD
12 LEAD STATOR. FOR GENERATOR CONNECTIONS SEE ADV–5875 THREE PHASE ADV–5857 SINGLE PHASE
MAG. PICK–UP
SHIELD WIRE ON 4 & 6 CYL. ONLY
ADV-6122-B

Figure 5-12 Logic Schematic, Decision-Maker™ 3+

5.1.2 Fault Shutdowns, Decision-Maker 3+ Controller

If the generator set does not start or stops running because of a fault shutdown (fault lamp lit), refer to Figure 5-13 to identify fault conditions. Consult the Engine Service Manual for detailed information on correcting engine-related faults. To reset the set after a fault shutdown, see Section 2, Operation.

Indicator	Fault Condition/Causes
High engine temperature lamp lights	Engine coolant temperature is above shutdown range; see Section 1, Specifications
	Cooling system malfunction
Low oil pressure lamp lights	Engine oil pressure is below shutdown range, see Section 1, Specifications
Overspeed lamp lights	Governed frequency is in excess of 70 Hz (2100 rpm)
Overcrank lamp lights	Continuous cranking is more than 45 seconds
	Cyclic cranking is more than 75 seconds
	Locked rotor
Overcrank lamp flashes	Speed sensor signal is absent longer than one second
Auxiliary lamp flashes	No AC output is present
	Battery power was reconnected or was low and then came back up again while generator set master switch was in the RUN or AUTO position
Auxiliary lamp lights	Optional emergency stop switch is reset while the generator set master switch is in the RUN or AUTO position
	High exhaust temperature (P1-14) or auxiliary delay shutdown (P1-15) faults occur, if sensor equipped
	Overvoltage, if equipped, has occurred, voltage 15% greater than nominal voltage (for period longer than two seconds)
	Activated by customer-supplied sensing device connected to auxiliary immediate shutdown ports (P1-17 and P1-18)
Emergency stop, if equipped	Emergency stop switch is activated (local or remote)
	Emergency stop switch(es) are disconnected from controller terminals TB1-1 or 1A
Multiple lamps light (where illumination may appear dim)	Main circuit board F1 (3-amp) fuse blown. F1 fuse supplies battery voltage to a remote annunciator and/or dry contact kit.

Figure 5-13 Fault Shutdown Troubleshooting Chart

5.2 Microprocessor Controller Relay Descriptions

A description of the controller and generator relays follows. Use this information to troubleshoot the generator set in conjunction with the troubleshooting microprocessor controller flowcharts on the following pages. Use the troubleshooting section following and the respective wiring diagram for additional information.

5.2.1 K1 Relay, Starter Solenoid

The K1 relay, located on the engine, energizes the starter.

5.2.2 K2 Relay, Crank Relay on Main Circuit Board

The K2 relay energizes the K1 relay. The LED2 lights when energized during crank mode. The K2 relay is located on the controller circuit board. See Figure 5-14.

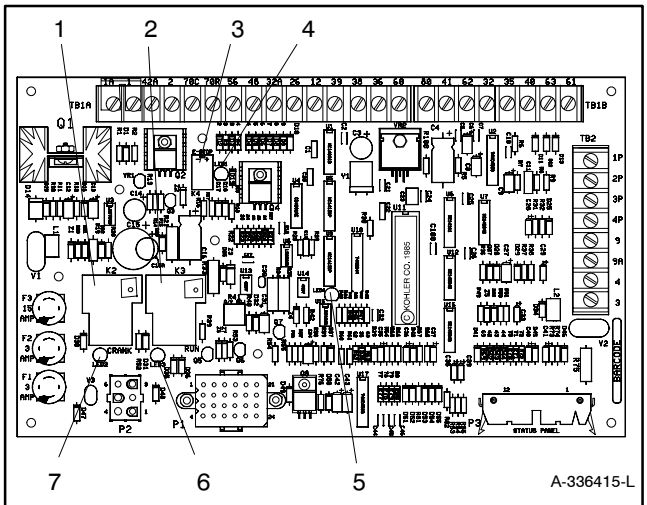
5.2.3 K3 Relay, Run Relay on Main Circuit Board

The K3 relay energizes the fuel solenoid and instrumentation.

The K3 relay also energizes the generator voltage regulator. LED3 lights when energized during crank and run modes. The K3 relay is located on the controller circuit board.

5.2.4 K4 Relay, Emergency Stop Relay on Main Circuit Board

The K4 relay is continuously energized except during emergency stop. LED4 is lit at all times except during emergency stop. The K4 relay is located on the controller circuit board. If the emergency stop kit is connected (local or remote), remove the jumper from circuit board TB1-1 and 1A. If no emergency stop kit is connected, a jumper must connect terminals TB1-1 and 1A. See Figure 5-14.



1. K2 relay
2. K3 relay
3. K4 relay
4. LED1
5. LED4
6. LED3
7. LED2

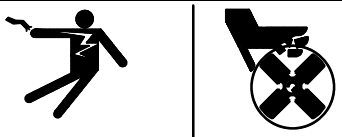
Figure 5-14 Main Circuit Board Relays

5.2.5 K5 Relay, Governor Control Relay

The K5 relay energizes the engine governor control circuit. The K5 relay is located in the generator junction box.

5.3 Microprocessor Controller

⚠ WARNING

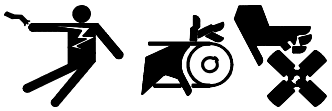


Hazardous voltage. Moving rotor. Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocution is possible whenever electricity is present. Open the main circuit breakers of all power sources before servicing the equipment. Configure the installation to electrically ground the generator set, transfer switch, and related equipment and electrical circuits to comply with applicable codes and standards. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

⚠ WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

5.3.1 Troubleshooting

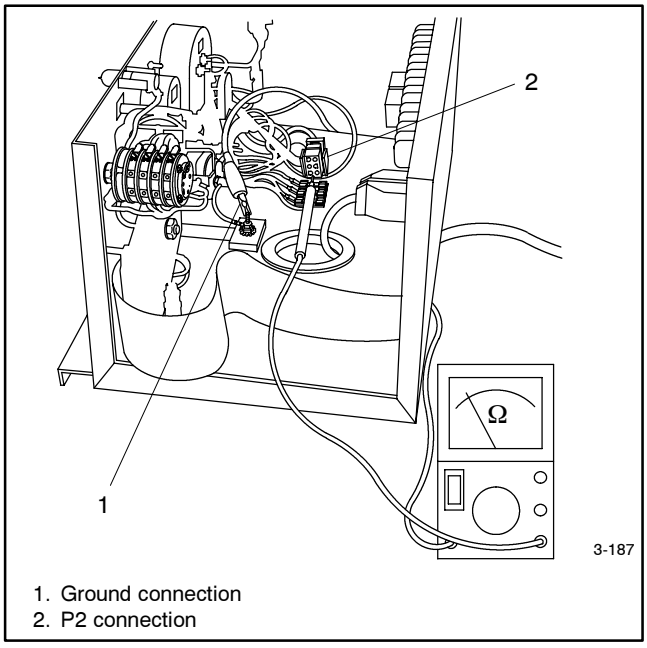
Use the following charts as a quick reference in troubleshooting individual problems. Consult the first chart for aid in locating the cause of blown fuses. In the successive charts, generator faults are listed by specific groups and correlated with possible causes and corrective action. Before beginning any troubleshooting procedure, read all safety precautions at the beginning of this manual and those included in the text. Do not neglect these precautions.

Note: If starting the unit by remote switch, verify proper operation of the remote switch before troubleshooting the controller. Test the remote switch operation by placing the generator set master switch in the AUTO position and running a jumper between terminals 3 and 4 on the controller circuit board. If the generator does not start, proceed with the controller troubleshooting procedure outlined in the following pages.

To quickly check the condition of the components mentioned in the following flowcharts, use an ohmmeter to read resistance between the designated terminal and ground. See Figure 5-16. With the ohmmeter on the R x 1 scale, a reading of less than one ohm (continuity) indicates that the component may be inoperative. Isolate the inoperative component and repair or replace it.

Component	Connect between ground and terminal:
Engine gauges	Connector P2, pin 1
Crank (K1 relay) circuit	Connector P1, pin 1
(Diesel) fuel solenoid circuit	Connector P1, pin 7

Figure 5-15 Checking P1 and P2 Connections



1. Ground connection
2. P2 connection

Figure 5-16 Checking P1 and P2 Connections

5.3.2 Fuses

The following chart lists the possible causes of blown controller fuses F1, F2, and F3. If a fuse blows, replace it and resume operation. If the fuse blows again, use Figure 5-17 to identify the faulty component(s).

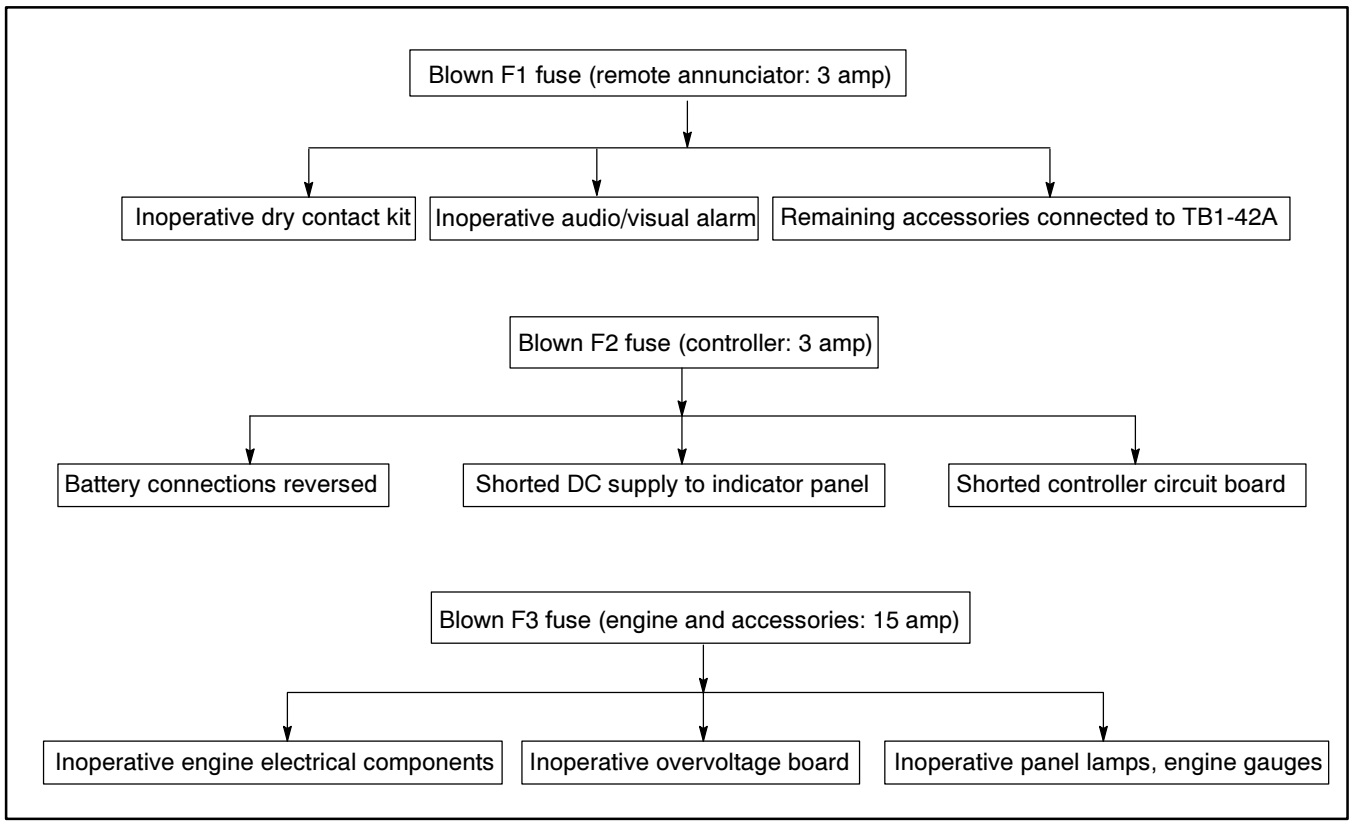

Blown F1 fuse (remote annunciator: 3 amp)
Inoperative dry contact kit
Inoperative audio/visual alarm
Remaining accessories connected to TB1-42A
Blown F2 fuse (controller: 3 amp)
Battery connections reversed
Shorted DC supply to indicator panel
Shorted controller circuit board
Blown F3 fuse (engine and accessories: 15 amp)
Inoperative engine electrical components
Inoperative overvoltage board
Inoperative panel lamps, engine gauges

Figure 5-17 Checking F1, F2, and F3 Fuses

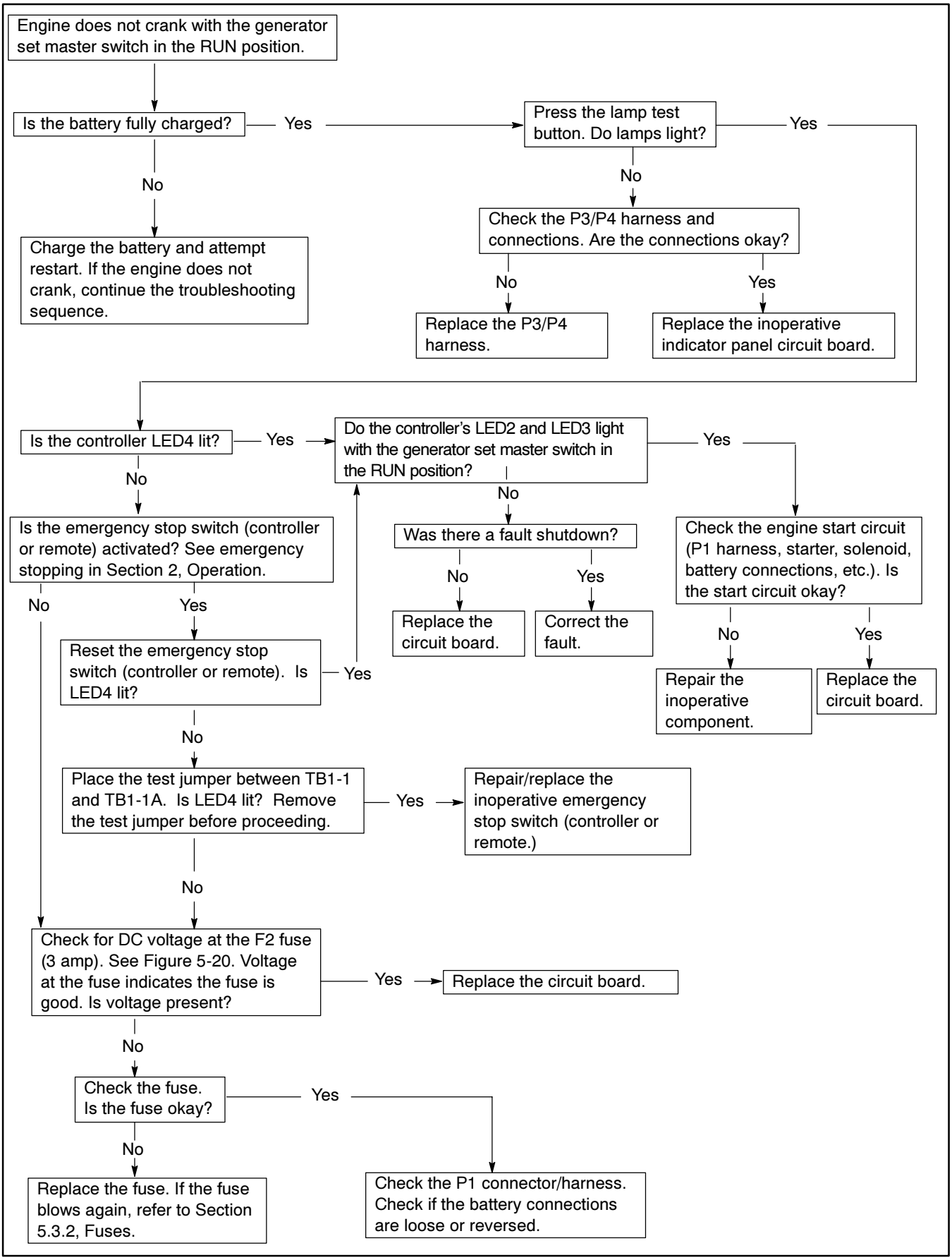

Engine does not crank with the generator set master switch in the RUN position.
Is the battery fully charged?
Yes
No
Charge the battery and attempt restart. If the engine does not crank, continue the troubleshooting sequence.
Press the lamp test button. Do lamps light?
Yes
No
Check the P3/P4 harness and connections. Are the connections okay?
No
Yes
Replace the P3/P4 harness.
Replace the inoperative indicator panel circuit board.
Is the controller LED4 lit?
Yes
No
Do the controller's LED2 and LED3 light with the generator set master switch in the RUN position?
Yes
No
Was there a fault shutdown?
No
Yes
Replace the circuit board.
Correct the fault.
Check the engine start circuit (P1 harness, starter, solenoid, battery connections, etc.). Is the start circuit okay?
No
Yes
Repair the inoperative component.
Replace the circuit board.
Is the emergency stop switch (controller or remote) activated? See emergency stopping in Section 2, Operation.
No
Yes
Reset the emergency stop switch (controller or remote). Is LED4 lit?
Yes
No
Place the test jumper between TB1-1 and TB1-1A. Is LED4 lit? Remove the test jumper before proceeding.
Yes
Repair/replace the inoperative emergency stop switch (controller or remote.)
No
Check for DC voltage at the F2 fuse (3 amp). See Figure 5-20. Voltage at the fuse indicates the fuse is good. Is voltage present?
Yes
Replace the circuit board.
No
Check the fuse. Is the fuse okay?
Yes
No
Replace the fuse. If the fuse blows again, refer to Section 5.3.2, Fuses.
Check the P1 connector/harness. Check if the battery connections are loose or reversed.

Figure 5-18 Engine Does Not Crank

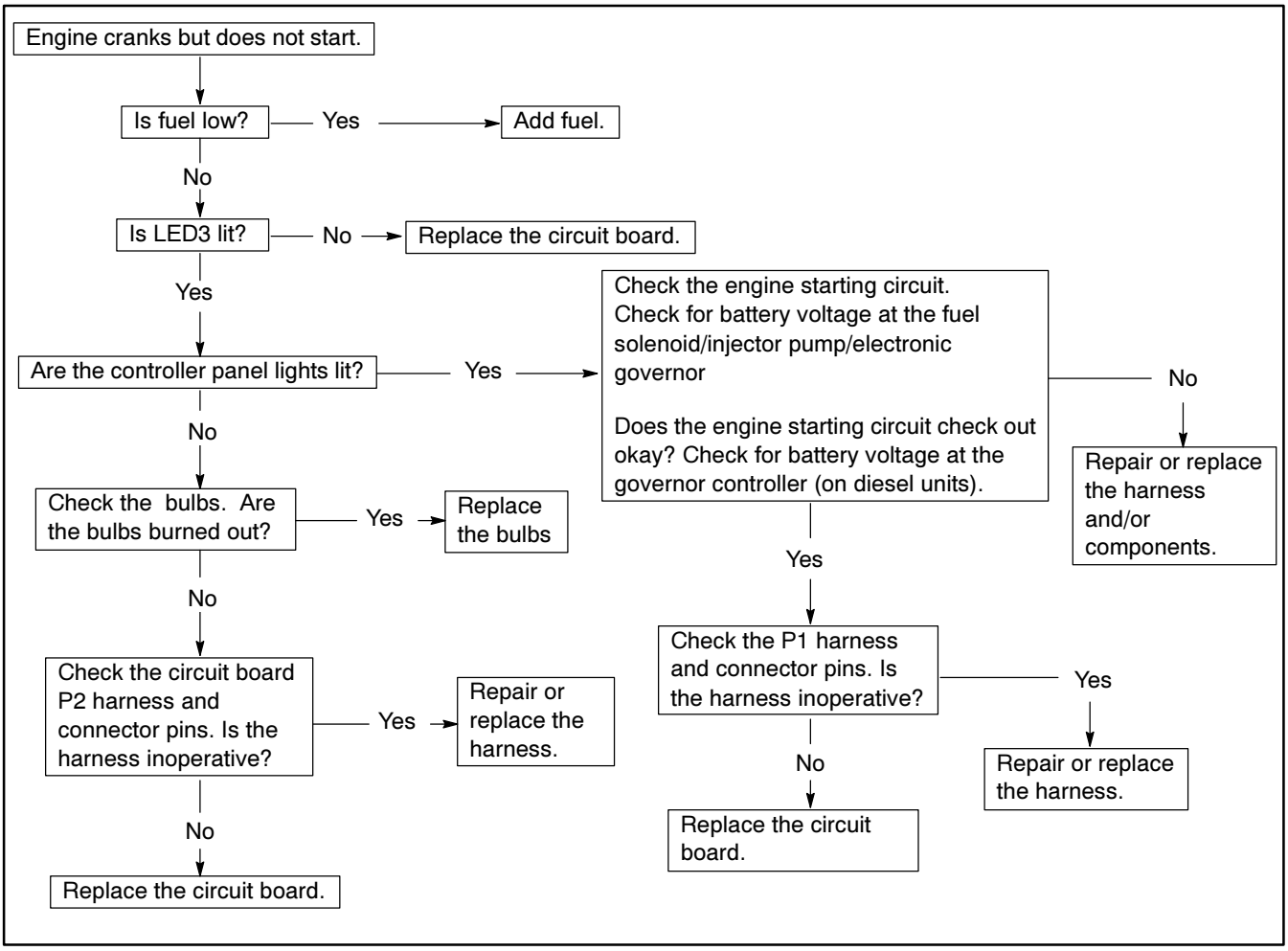
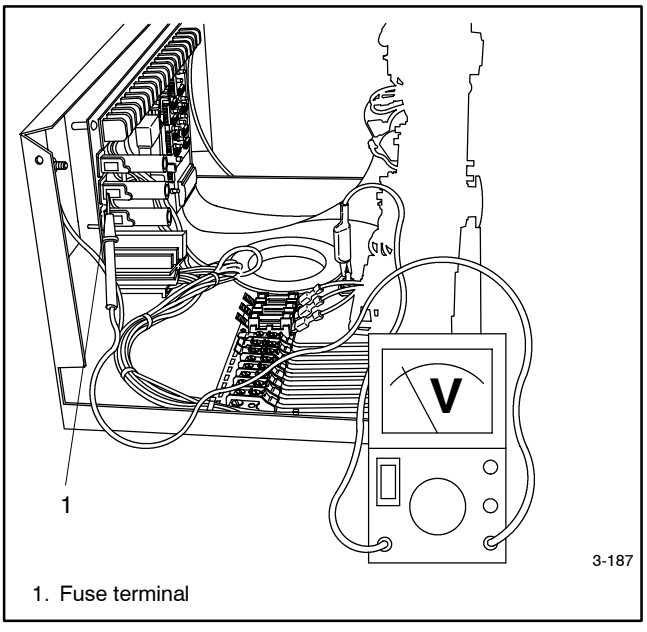
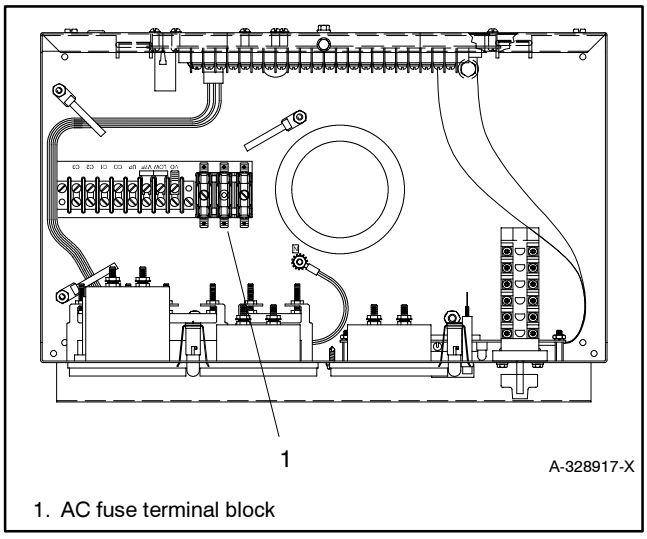

Engine cranks but does not start.
Is fuel low?
Yes
Add fuel.
No
Is LED3 lit?
No
Replace the circuit board.
Yes
Are the controller panel lights lit?
Yes
Check the engine starting circuit.
Check for battery voltage at the fuel solenoid/injector pump/electronic governor
Does the engine starting circuit check out okay? Check for battery voltage at the governor controller (on diesel units).
No
Repair or replace the harness and/or components.
No
Check the bulbs. Are the bulbs burned out?
Yes
Replace the bulbs
Yes
No
Check the circuit board P2 harness and connector pins. Is the harness inoperative?
Yes
Repair or replace the harness.
Check the P1 harness and connector pins. Is the harness inoperative?
Yes
Repair or replace the harness.
No
Replace the circuit board.
No
Replace the circuit board.

Figure 5-19 Engine Cranks, But Does Not Start



1. Fuse terminal

Figure 5-20 Checking Condition of F2 Fuse



1. AC fuse terminal block

Figure 5-21 AC Fuse Terminal Block

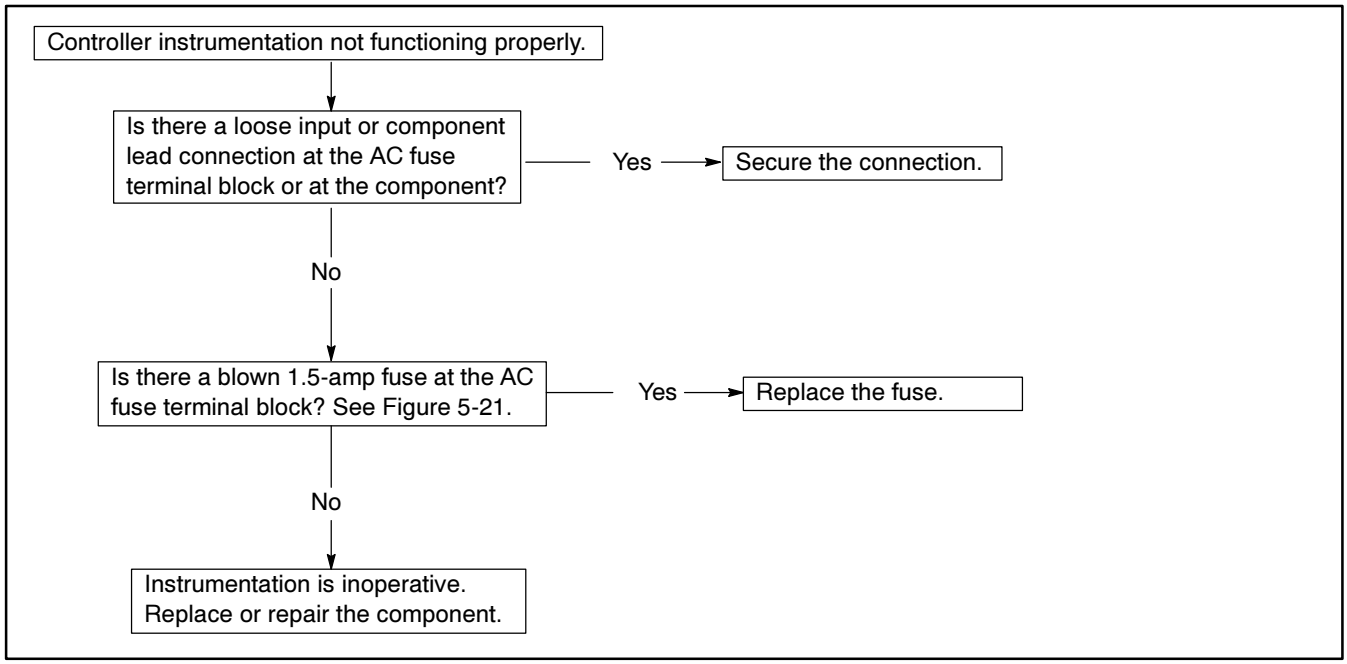

Controller instrumentation not functioning properly.
Is there a loose input or component lead connection at the AC fuse terminal block or at the component?
Yes
Secure the connection.
No
Is there a blown 1.5-amp fuse at the AC fuse terminal block? See Figure 5-21.
Yes
Replace the fuse.
No
Instrumentation is inoperative. Replace or repair the component.

Figure 5-22 Controller Instrumentation

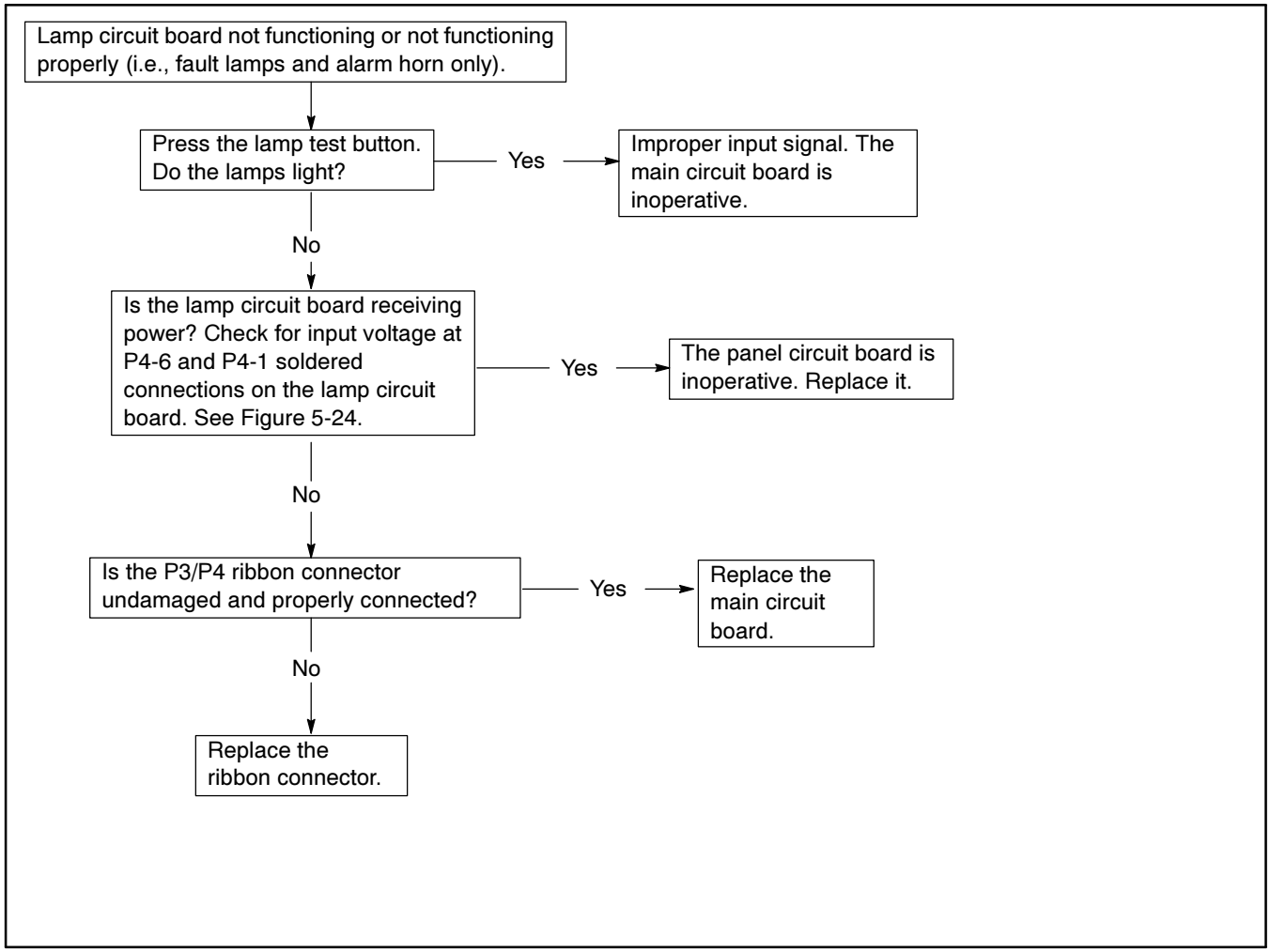
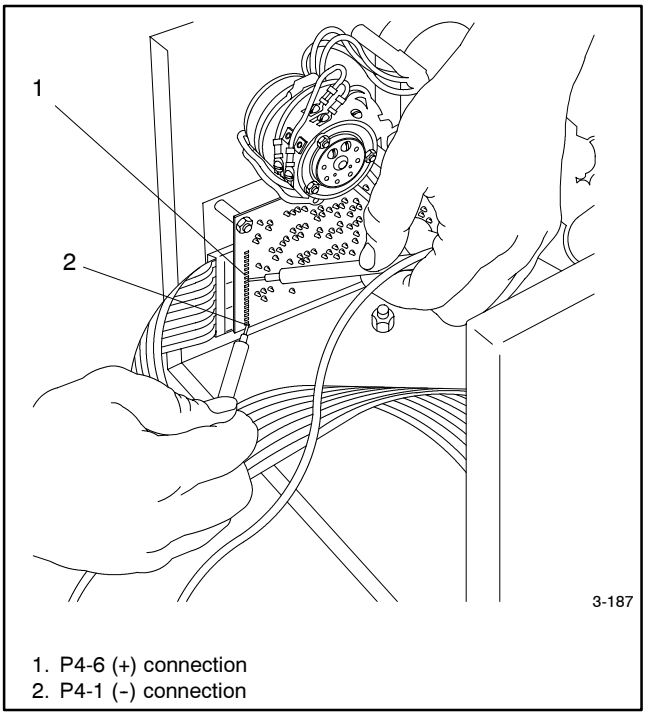

Lamp circuit board not functioning or not functioning properly (i.e., fault lamps and alarm horn only).
Press the lamp test button. Do the lamps light?
Yes
Improper input signal. The main circuit board is inoperative.
No
Is the lamp circuit board receiving power? Check for input voltage at P4-6 and P4-1 soldered connections on the lamp circuit board. See Figure 5-24.
Yes
The panel circuit board is inoperative. Replace it.
No
Is the P3/P4 ribbon connector undamaged and properly connected?
Yes
Replace the main circuit board.
No
Replace the ribbon connector.

Figure 5-23 Lamp Circuit Board



1. P4-6 (+) connection
2. P4-1 (–) connection

Figure 5-24 Checking Input to Lamp Circuit Board

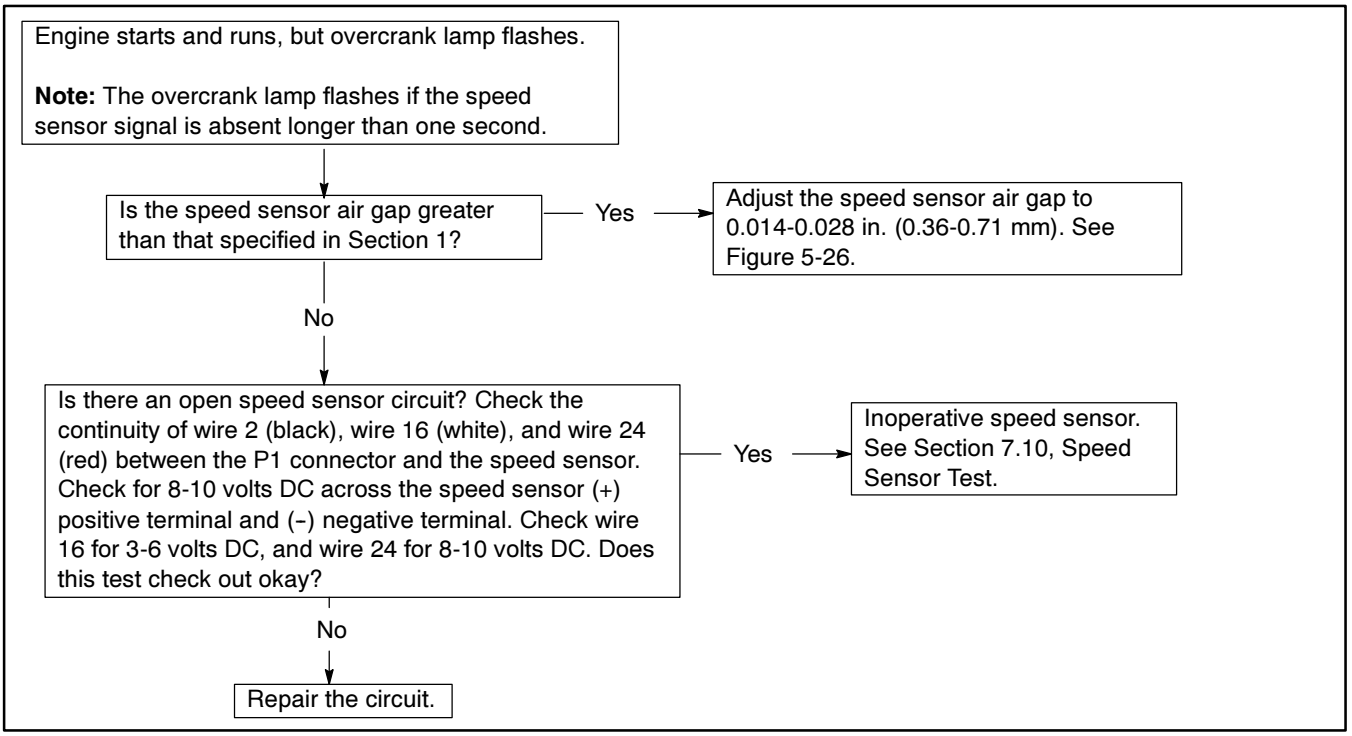
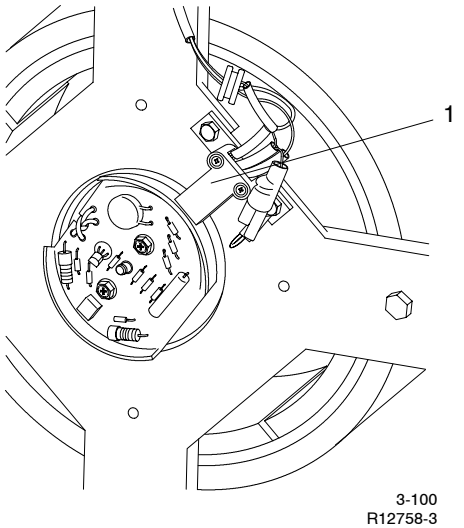
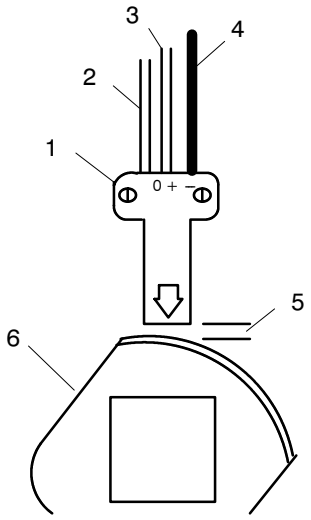

Engine starts and runs, but overcrank lamp flashes.
Note: The overcrank lamp flashes if the speed sensor signal is absent longer than one second.
Is the speed sensor air gap greater than that specified in Section 1?
Yes
Adjust the speed sensor air gap to 0.014-0.028 in. (0.36-0.71 mm). See Figure 5-26.
No
Is there an open speed sensor circuit? Check the continuity of wire 2 (black), wire 16 (white), and wire 24 (red) between the P1 connector and the speed sensor. Check for 8-10 volts DC across the speed sensor (+) positive terminal and (–) negative terminal. Check wire 16 for 3-6 volts DC, and wire 24 for 8-10 volts DC. Does this test check out okay?
Yes
Inoperative speed sensor. See Section 7.10, Speed Sensor Test.
No
Repair the circuit.

Figure 5-25 Overcrank Lamp





1. Speed sensor
2. Wire 16: white/clear
3. Wire 24: red
4. Wire 2: black
5. Air gap: 0.36–0.71 mm (0.014–0.028 in.)
6. Actuator cup

Figure 5-26 Speed Sensor Air Gap

5.4 FASTCHECK Features and Operation

The FASTCHECK® serves as an engine simulator for testing and troubleshooting the microprocessor controller.

5.4.1 Features

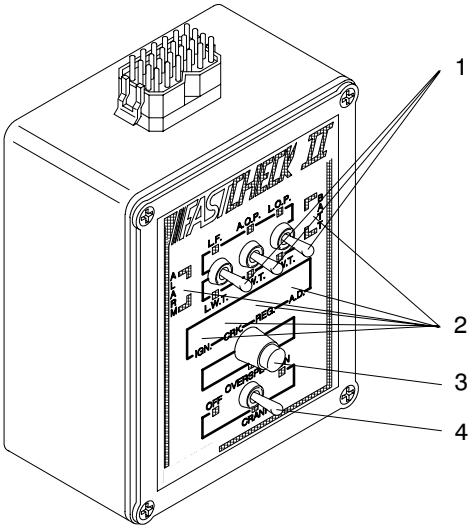
The following paragraphs detail the FASTCHECK® features. See Figure 5-27 for an illustration. The following engine switch positions simulate engine conditions:

- OFF—locked engine (starter energized but not turning)
- CRANK—engine cranking, but not started
- RUN—engine running

Indicator Lamps:

- IGN—(ignition) lamp:
  - Shows battery voltage supplied to fuel solenoid
  - Lights during cranking and running
- CRK—(crank) lamp:
  - Shows battery voltage switched to starter (engine not necessarily turning)
  - Lights only during on-crank cycles
- REG—(regulator) lamp:
  - Shows battery voltage supplied to the generator set's AC voltage regulator
  - Lights only during cranking and running
- BATT—(battery) lamp:
  - Lights when the test battery(ies) or DC power supply is live and properly connected

Note: LOP, HWT, and OVERSPEED simulate malfunctions causing the engine to shut down. LOP and HWT circuits start timing after the engine has run for 30 seconds. The engine shutdown should occur 5 seconds after pushing the fault switch.



1. Toggle switches
2. Indicator lamps
3. Overspeed button
4. Engine switch

Figure 5-27 FASTCHECK® Simulator

Switches:

- LOP—low oil pressure
- HWT—high water (engine) temperature
- OVERSPEED—simulates a 70 Hz overspeed condition
- LF—low fuel (not used for testing)
- LWT—low engine water temperature
- AOP—anticipatory (low) oil pressure
- AWT—anticipatory (high) water temperature

5.4.2 Application

Use the FASTCHECK® to test the microprocessor controller on the generator set when troubleshooting startup problems or to test and troubleshoot the controller when removed from the generator set.

To operate the FASTCHECK® the following equipment is required:

- FASTCHECK® simulator (B-291930) and harness (255915).
- Variable low-voltage DC power supply; 0–30 volt, 3 amp minimum current, 0.5% maximum output voltage ripple at 30 volts DC. A 12- or 24-volt battery (depending on system voltage) can also be used to operate the FASTCHECK®.

5.4.3 Connect/Operate Procedure

Use the following procedure to connect/operate the FASTCHECK® tester.

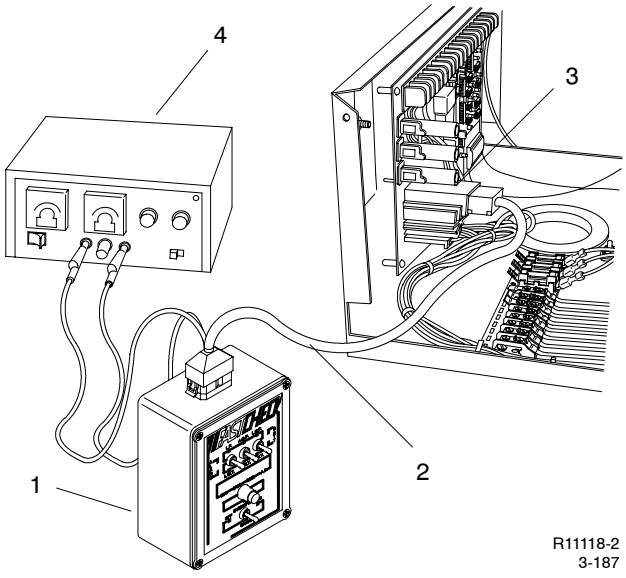
Procedures to test the overcrank circuitry, speed sensor circuitry, and generator condition indicators are described later in this section.

1. Unplug the DC engine harness from the DC harness connector (P1). See Figure 5-28.
2. Connect the FASTCHECK® harness to the DC harness connector (P1) and to the top of the FASTCHECK®.
3. Move the generator set master switch to the OFF/RESET position.
4. Move the FASTCHECK® engine switch to the OFF position.
5. Clip the red (+) and black (–) harness leads to a battery(ies) or DC power supply of proper voltage for the generator set (12 or 24 volts). Adjust the output voltage to 1-2 volts above battery voltage when using a DC power supply. See the BATT rating on the generator nameplate. Use the generator set battery(ies) if accessible and fully charged.

   Note: Observe the correct polarity when connecting FASTCHECK®, otherwise circuit board damage occurs.

   Note: Because of the absence of AC output, the auxiliary lamp flashes during controller testing (on 16-light microprocessor controllers). The NOT-IN-AUTO lamp illuminates whenever the generator set master switch is not in the AUTO position on 16-light microprocessor controllers.

6. Move the generator set master switch to the RUN position. Move the FASTCHECK® engine switch to the CRANK position. The FASTCHECK® IGN, CRK, and REG lamps should light. The generator controller causes the engine to crank until the FASTCHECK® switch is moved to the RUN position (or OVERCRANK shutdown appears on generator controller).
7. Move the FASTCHECK® engine switch to the RUN position. CRK lamp should go out and REG and IGN lamps should stay on.



1. FASTCHECK®
2. Wiring harness
3. DC harness connector
4. DC power supply

Figure 5-28 FASTCHECK® Connections

8. Simulate engine malfunctions by pressing FASTCHECK® fault switches. The corresponding fault lamp on the controller should light during each simulated engine malfunction.

   Note: Leave the FASTCHECK® engine switch in the RUN position for at least 30 seconds before pushing toggle switches. Toggle the generator set master switch to the OFF/RESET position and the FASTCHECK® engine switch to the OFF position, then back to the RUN position after simulated fault shutdowns.

5.4.4 Overcrank

Use the following procedure to test the controller's ability to detect a locked engine and to stop a startup attempt if the starter locks or does not engage.

Overcrank Circuitry Test Procedure

1. Move the FASTCHECK® engine switch to the OFF position.

2. Move the generator set master switch to the OFF position and then move the switch to the RUN position.

3. IGN, CRK, and REG lamps on FASTCHECK® should light for approximately 5 seconds and then go out. Five seconds later, the IGN, CRK, and REG lamps should relight for 5 seconds before going out again (15 seconds total elapsed time). The controller OVERCRANK lamp lights. Check for operating voltage between TB1-42A (+) and TB1-12 (–).

4. This test verifies the proper operation of the engine overcrank circuit. If the OVERCRANK shutdown fails to function, check the speed sensor and related circuitry. See Section 5.4.5, Controller Speed Sensor Circuitry, and Section 7.10, Speed Sensor Test.

5.4.5 Controller Speed Sensor Circuitry

To check the controller's ability to respond to signals from the speed sensor, perform the following test:

Speed Sensor Circuitry Test Procedure

1. Move the generator set master switch to the OFF/RESET position.

2. Move the FASTCHECK® engine switch to the OFF position.

3. Move the generator set master switch to the RUN position. Observe the IGN, CRK, and REG lamps light.

4. Within 5 seconds, move the FASTCHECK® engine switch to the RUN position.

5. If the FASTCHECK® CRK lamp goes out, the controller speed sensor circuitry is functioning correctly.

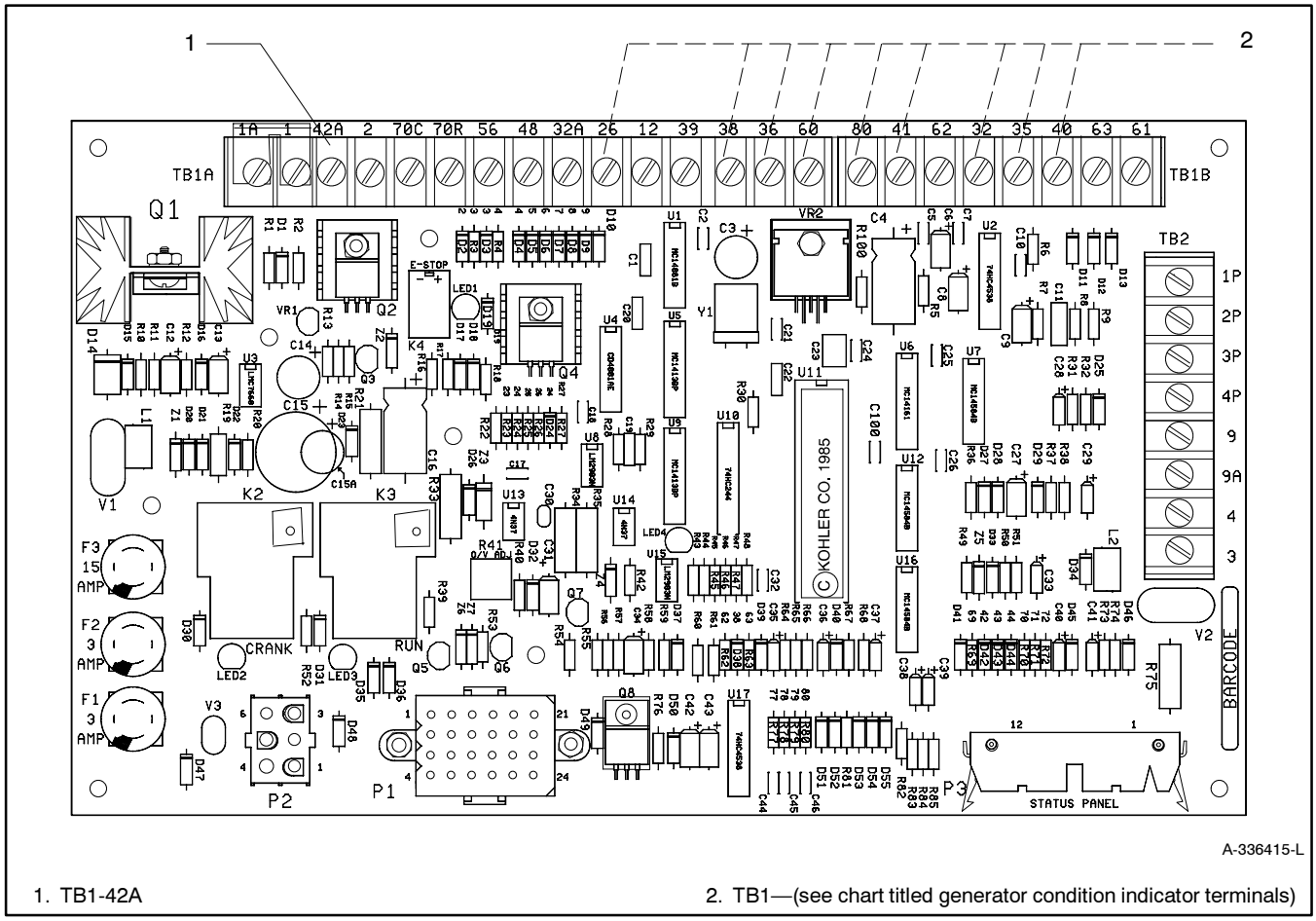
5.4.6 Generator Condition Indicator Terminal (TB1 Terminal Strip)

Remote accessories (audiovisual alarm, remote annunciator, dry contact kits, etc.) may be connected to the controller TB1 terminal strip to signal the condition of the generator set. Some generator sets may not be equipped with the optional sending devices necessary to operate all generator condition indicators. If the remote accessories do not operate, test for output voltage at the TB1 terminal strip. To test the operation of each indicator, move the generator set master switch and FASTCHECK® toggle in the position prescribed. Test point voltage is slightly less than the voltage being supplied to the controller (12 or 24 volts). If correct voltage is not detected at the test point, remote accessories (audiovisual alarm, remote annunciator, dry contact kits, etc.) do not function. Test point connections are shown in Figure 5-29 and Figure 5-30.

Note: When checking controller test point voltage, place the negative (–) lead of the voltmeter on the terminal designated in Figure 5-30 and the voltmeter positive (+) lead on TB1-42A.

Note: Because of the absence of AC output, the auxiliary lamp flashes during the controller testing on 16-light microprocessor controllers. The NOT-IN-AUTO lamp illuminates whenever the generator set master switch is not in the AUTO position on 16-light microprocessor controllers.

Note: Leave the FASTCHECK® engine switch in the RUN position for at least 30 seconds before pushing the toggle switches. Toggle the generator set master switch to the OFF/RESET position. Move the FASTCHECK® engine switch to the OFF position. Move the generator set master switch to the RUN position. Observe IGN, CRK, and REG lamps light. Within 5 seconds, move the FASTCHECK® engine switch to the RUN position.



1. TB1-42A
2. TB1—(see chart titled generator condition indicator terminals)

Figure 5-29 Indicator Lamp Test Connections

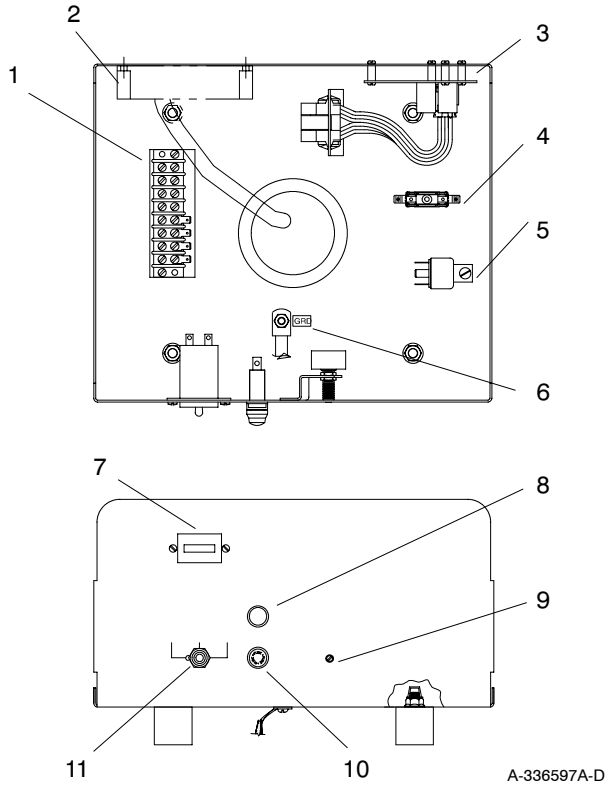
Indicator	Switch Position/Remarks	Check For Voltage Between
System Ready	Master switch in AUTO position; engine switch in OFF position.	TB1-42A (+) and TB1-60 (-)
High (Engine) Water Temperature (HWT)	Master switch in RUN position; engine switch in RUN position; hold toggle switch to HWT for at least 5 seconds	TB1-42A (+) and TB1-36 (-)
Low Oil Pressure (LOP)	Master switch in RUN position; engine switch in RUN position; hold toggle switch to LOP for at least 5 seconds	TB1-42A (+) and TB1-38 (-)
Auxiliary Fault (16-light controller)	Master switch in RUN position; engine switch in RUN position; wait 10 seconds. A flashing AUX lamp indicates proper operation of all auxiliary functions	TB1-42A (+) and TB1-26 (-)
Emergency Stop (local/remote), if equipped	Master switch in RUN position; engine switch in RUN position; remove switch lead connected to controller terminals TB1-1 or 1A.	Not Applicable
Generator Switch Not-in-Auto	Master switch in RUN or OFF/RESET; engine switch in any position	TB1-42A (+) and TB1-80 (-)
Anticipatory (High Engine) Water Temperature (AWT)	Master switch in RUN position; engine switch in RUN; hold toggle switch to AWT	TB1-42A (+) and TB1-40 (-)
Anticipatory (Low Engine) Oil Pressure (AOP)	Master switch in RUN position; engine switch in RUN; hold toggle switch to AOP	TB1-42A (+) and TB1-41 (-)
Low Water Temperature (LWT), if equipped	Master switch in RUN position; engine switch in RUN; hold toggle switch to LWT	TB1-42A (+) and TB1-35 (-)
Low Fuel, if equipped	Generator set master switch in OFF/RESET; engine switch in RUN position Ground controller terminal TB1-63 to test. If the Low Fuel lamp lights, the circuit is functioning correctly	Not Applicable
Battery Charger Fault (if battery charger equipped and connected)	Generator set master switch in OFF/RESET; engine switch in RUN position Ground controller terminal TB1-61 to test. If the Battery Charger lamp lights, the circuit is functioning correctly	Not Applicable
Low Battery Volts (if battery charger equipped and connected)	Generator set master switch in OFF/RESET; engine switch in RUN position Ground controller terminal TB1-62 to test. If the Low Battery Volts lamp lights, the circuit is functioning correctly	Not Applicable
Overspeed	See Section 5.4.5, Controller Speed Sensor Circuitry.	Not Applicable
Overcrank	See Section 5.4.4, Overcrank.	Not Applicable
Auxiliary Prealarm (Common Fault)	Master switch in RUN position; engine switch in RUN position; hold toggle switch to LWT, HWT, or LOP	TB1-42 (+) and TB1-32 (-)

Figure 5-30 Generator Condition Indicator Terminals

Notes

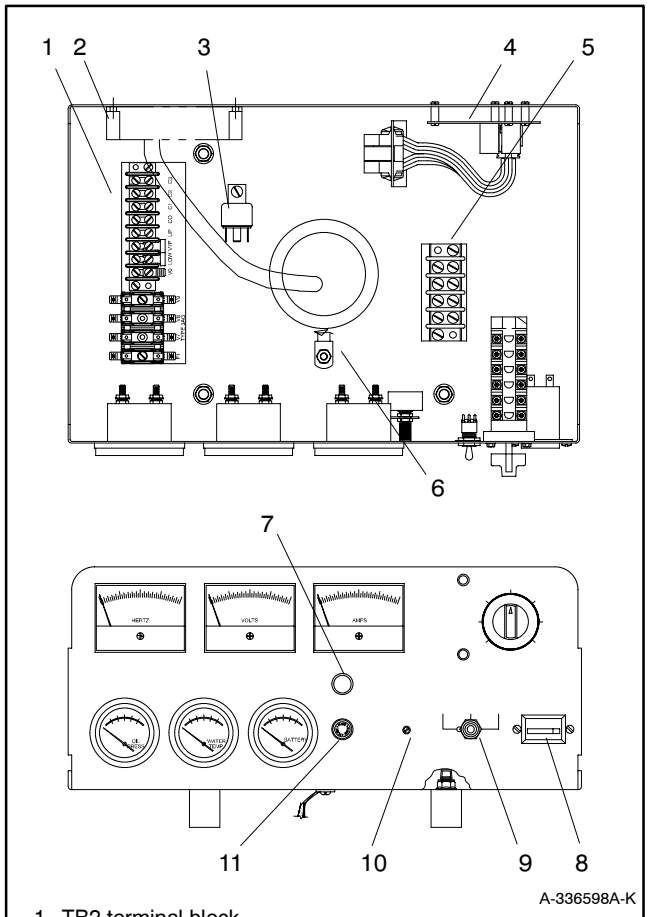
6.1 Decision-Maker™ 1 and Decision-Maker™ 1 Expanded Relay Controller

The following text covers the relay controller sequence of operation during generator start, run, stop, and fault shutdown modes. Use this information as a starting point for controller fault identification. See Section 2 to identify controller external components. See Figure 6-1 and Figure 6-2 to identify internal components of the relay controller. Use the LEDs on the controller circuit board to assist in the troubleshooting process. An illuminated LED indicates the respective relay is receiving power; the LED does not indicate whether that relay is energized. See Figure 6-3 and Figure 6-4.



1. TB1 AC terminal block
2. Governor
3. Controller main circuit board (E-254717 COZ models or F-254717 EOZ models)
4. 15-amp fuse
5. K5 relay
6. Ground strap
7. Hourmeter (front panel)
8. Fault lamp (front panel)
9. Voltage adjust potentiometer (front panel)
10. 10-amp fuse (front panel)
11. Generator set master switch (front panel)

Figure 6-1 Decision-Maker™ 1 Relay Controller Internal Components



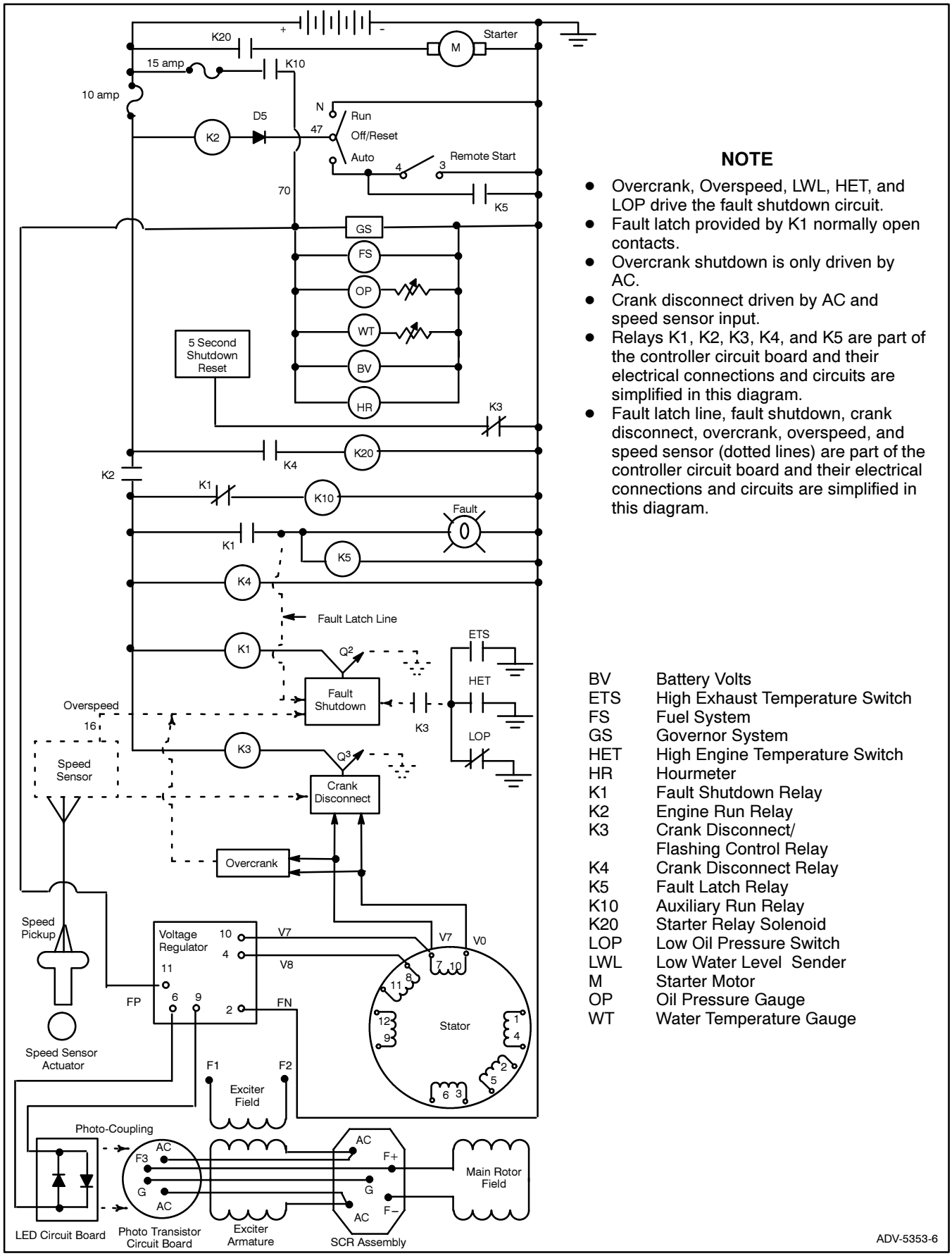
1. TB2 terminal block
2. Governor
3. K5 relay
4. Controller main circuit board (E-254717 COZ models or F-254717 EOZ models)
5. TB1 AC terminal block
6. Ground strap
7. Fault lamp (front panel)
8. Hourmeter (front panel)
9. Generator set master switch (front panel)
10. Voltage adjust potentiometer (front panel)
11. 10-amp fuse (front panel)

Figure 6-2 Decision-Maker™ 1 Expanded Relay Controller Internal Components

A change in the circuit board affects the function of some relays. Circuit board E-254717 has four internal relays with an external K5 relay for engine run components. Circuit board F-254717 has five relays with an external K10 relay for engine run components. The fifth relay designated K5 latches the fault lamp during fault shutdown when in the auto/remote start mode. Although the circuit boards are similar, the changes relating to K5/K10 alter the troubleshooting information.

Function	Relay	Relay Contact Normal Position	Relay Contact Action	Energizes/Action:
Starting: Close the start/stop switch between N and 47. **Note**: Fault shutdowns are inhibited during startup until K3 energizes.				K2 relay and LED2 lights
	K2	Open	Close	K10 relay (with F-254717) or K5 relay (with E-254717, engine components (fuel system, governor, ignition, etc.), K4 relay, and LED4 lights
	K10 or K5	Open	Close	Hourmeter on Decision-Maker™ 1 and Decision-Maker™ 1 Expanded controllers and engine gauges (battery voltage, water temperature, and oil pressure) on Decision-Maker™ 1 Expanded controllers
	K4	Open	Close	K20 relay
	K20	Open	Close	Starter motor
Running: Generator winding 7-10 produces AC output. **Note**: K3 relay must obtain AC output within 30 seconds or overcrank fault occurs.				K3 relay and LED3 lights
	K3	Closed	Open	Deenergizes K4 relay and LED4 deenergizes
	K4	Open	Open	Deenergizes starter motor
Stopping: Move the start/stop switch to open circuit between N and 47.				Deenergizes K2 relay and LED2 deenergizes
	K2	Open	Open	Deenergizes engine components; generator set shuts down
Fault shutdowns: Low oil pressure (LOP), high engine temperature (HET) after the engine operating temperature reaches 103°C (218°F), and high exhaust temperature (ETS) (wet exhaust only) after the exhaust temperature reaches 88-102°C (190-215°F). Contacts close 5-8 seconds after reaching shutdown level. **Note**: The fault shutdown latches to keep the fault lamp lit. Move the generator set master switch to OFF/RESET.				K1 relay, LED1 lights, and fault lamp
	K1	Closed	Open	Deenergizes engine components; generator set shuts down
Fault shutdown: Overspeed (OS). Contacts close when engine speed reaches shutdown level. Factory set at 70 Hz. **Note**: The fault shutdown latches to keep fault lamp lit. Move the generator set master switch to OFF/RESET.				K1 relay, LED1 lights, and fault lamp
	K1	Closed	Open	Deenergizes engine components; generator set shuts down
Fault shutdown: Overcrank (OC). Contacts close on overcrank (locked rotor) if the speed sensor signal is absent longer than 30 seconds. **Note**: The fault shutdown latches to keep the fault lamp lit. Move the generator set master switch to OFF/RESET.				K1 relay, LED1 lights, and fault lamp
	K1	Closed	Open	Deenergizes engine components; generator set shuts down

Figure 6-3 Relay Controller Sequence of Operation



NOTE

- Overcrank, Overspeed, LWL, HET, and LOP drive the fault shutdown circuit.
- Fault latch provided by K1 normally open contacts.
- Overcrank shutdown is only driven by AC.
- Crank disconnect driven by AC and speed sensor input.
- Relays K1, K2, K3, K4, and K5 are part of the controller circuit board and their electrical connections and circuits are simplified in this diagram.
- Fault latch line, fault shutdown, crank disconnect, overcrank, overspeed, and speed sensor (dotted lines) are part of the controller circuit board and their electrical connections and circuits are simplified in this diagram.

BV	Battery Volts
ETS	High Exhaust Temperature Switch
FS	Fuel System
GS	Governor System
HET	High Engine Temperature Switch
HR	Hourmeter
K1	Fault Shutdown Relay
K2	Engine Run Relay
K3	Crank Disconnect/ Flashing Control Relay
K4	Crank Disconnect Relay
K5	Fault Latch Relay
K10	Auxiliary Run Relay
K20	Starter Relay Solenoid
LOP	Low Oil Pressure Switch
LWL	Low Water Level Sender
M	Starter Motor
OP	Oil Pressure Gauge
WT	Water Temperature Gauge

Figure 6-4 Relay Controller Sequence of Operation with F-254717 and Later Circuit Boards

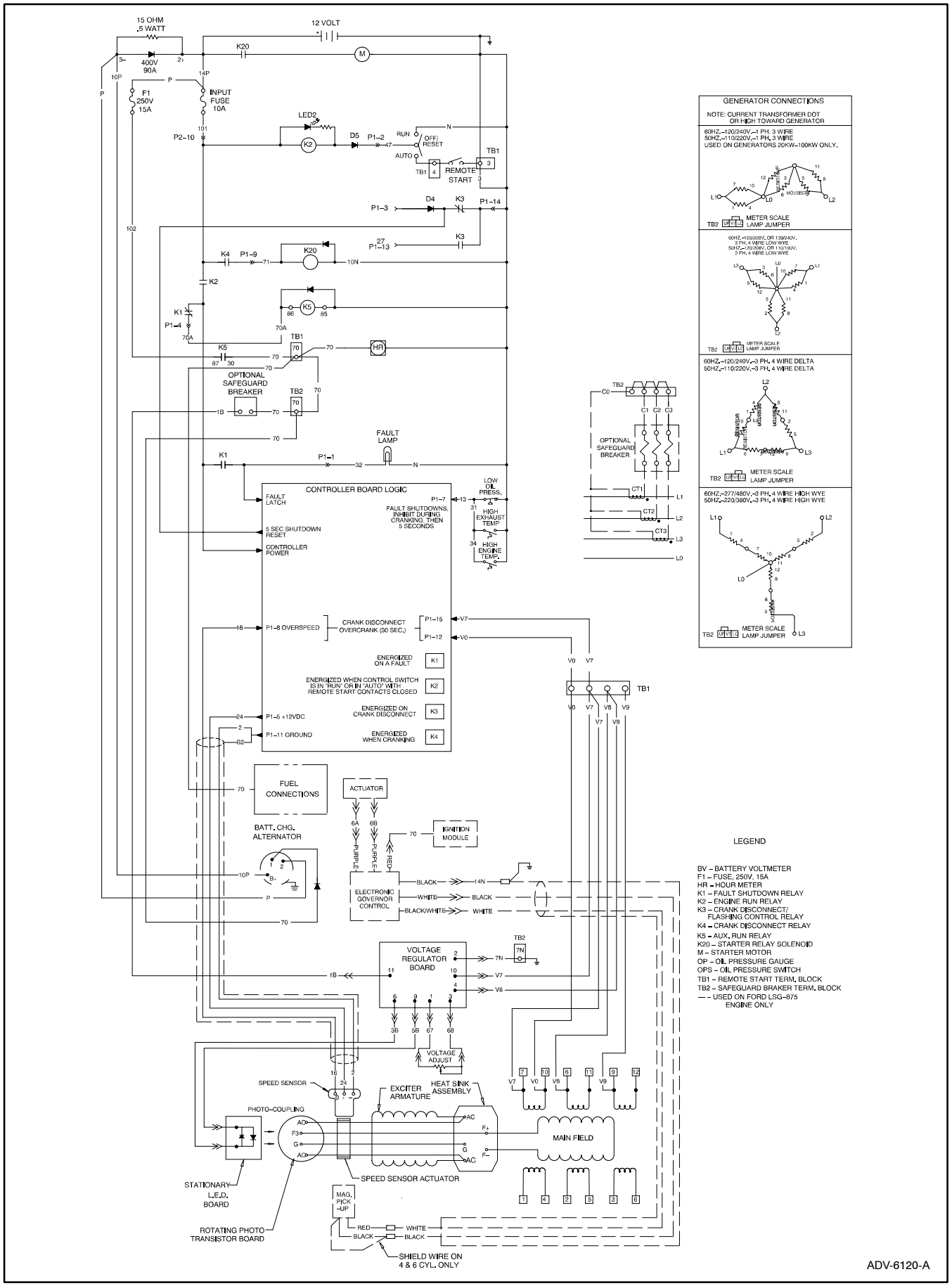


Figure 6-5 Decision-Maker™ 1 Relay Controller with E-254717 Circuit Board

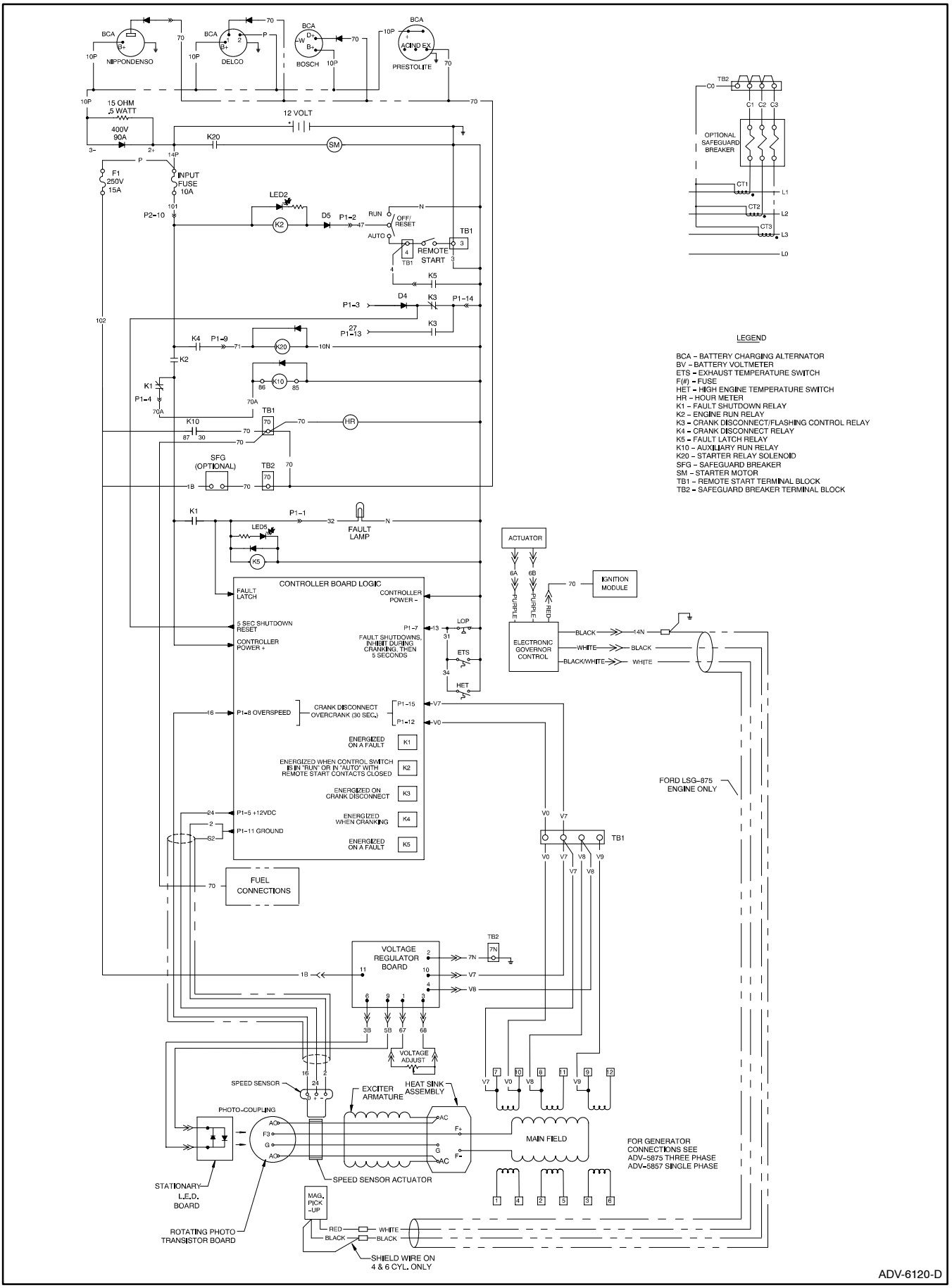


Figure 6-6 Decision-Maker™ 1 Relay Controller with F-254717 Circuit Board

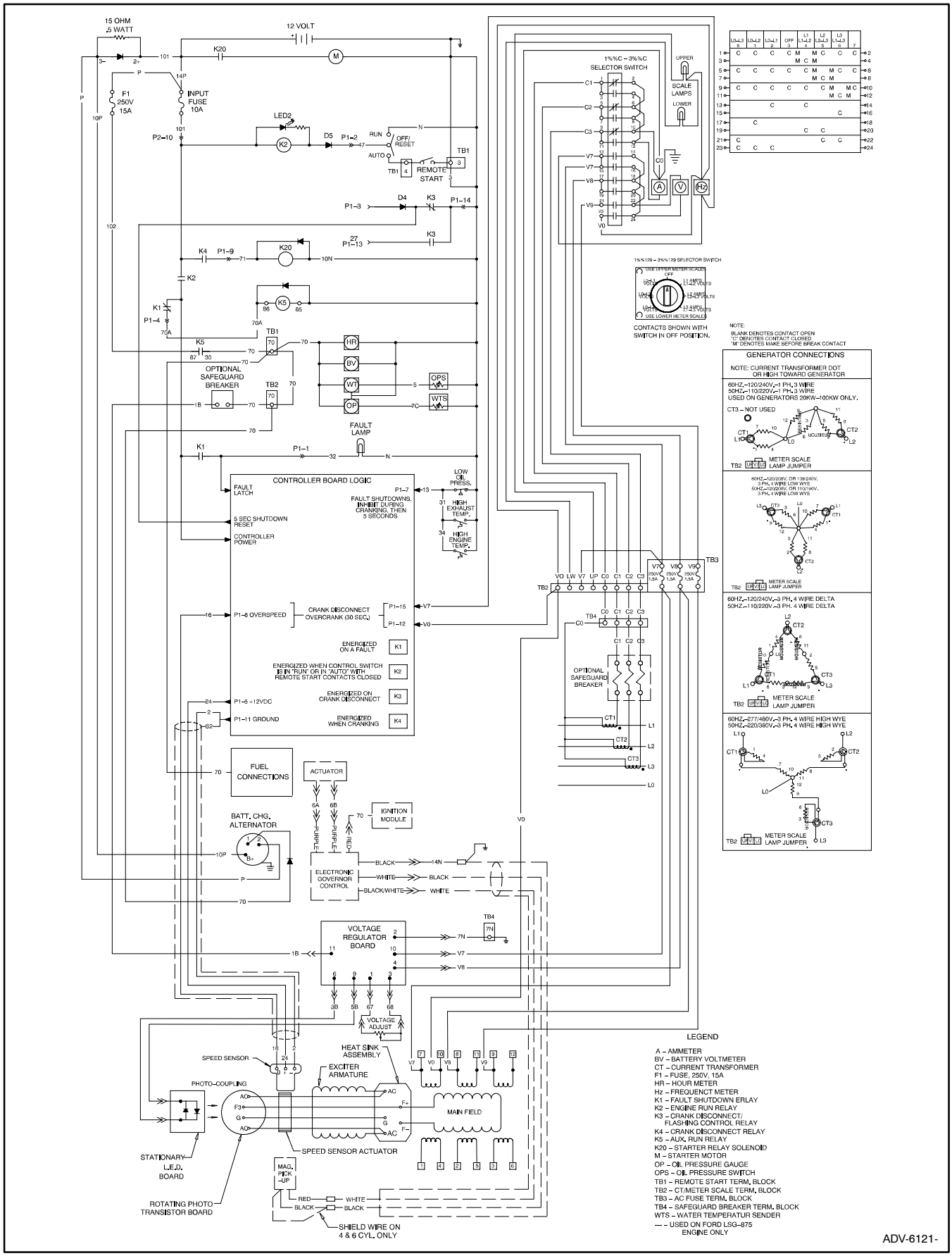


Figure 6-7 Decision-Maker™ 1 Expanded Relay Controller with E-254717 Circuit Board

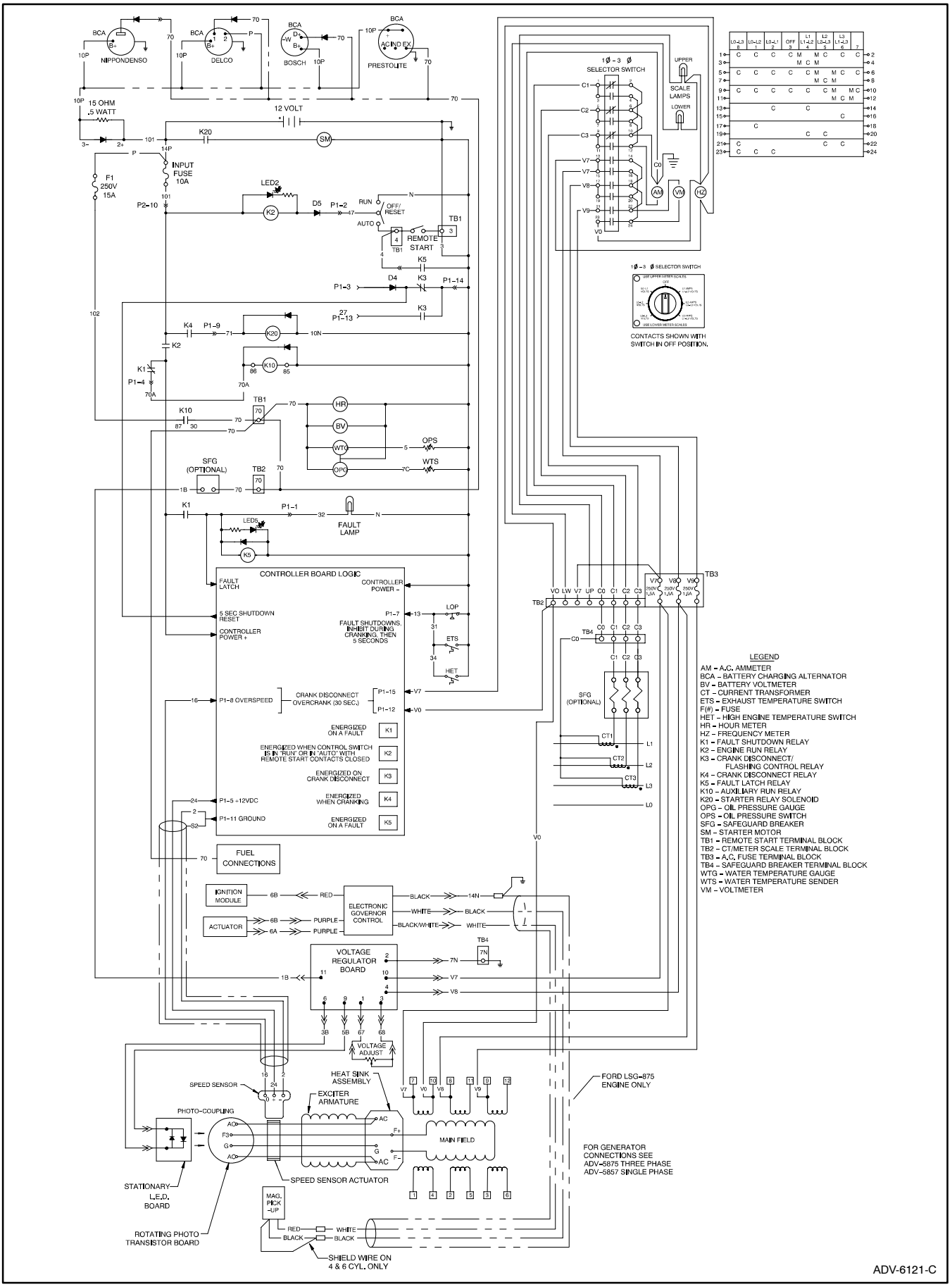
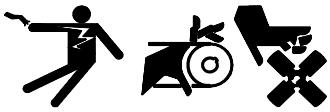


Figure 6-8 Decision-Maker™ 1 Expanded Relay Controller with F-254717 Circuit Board

6.2 Relay Controller

Use the following charts as a reference in troubleshooting individual problems. Before beginning any troubleshooting procedure, read all safety precautions at the beginning of this manual and those included in the text. Do not neglect these precautions.

⚠ WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

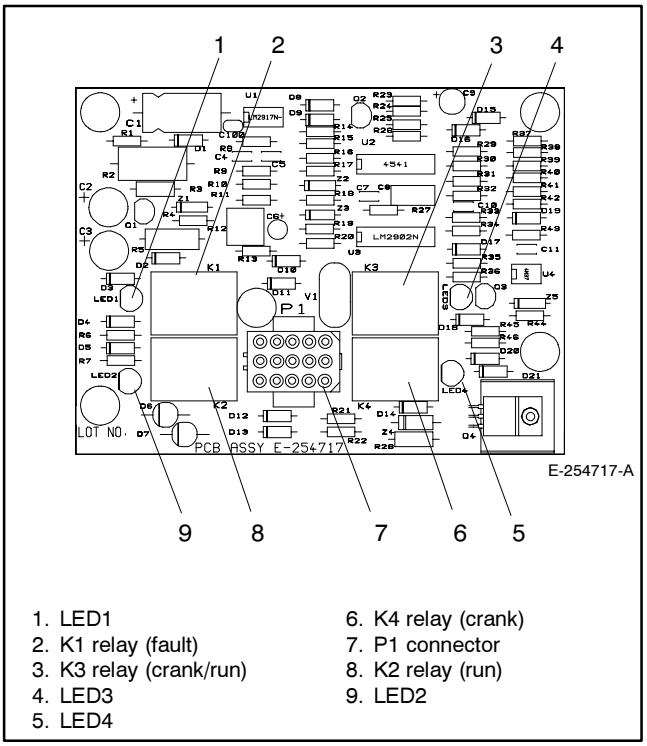
⚠ WARNING

Hazardous voltage. Moving rotor.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

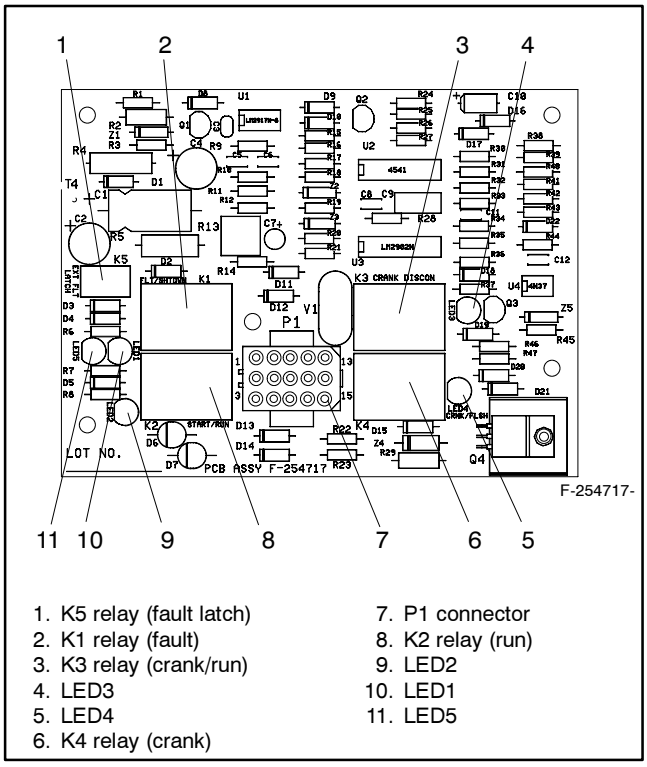
Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocution is possible whenever electricity is present. Open the main circuit breakers of all power sources before servicing the equipment. Configure the installation to electrically ground the generator set, transfer switch, and related equipment and electrical circuits to comply with applicable codes and standards. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

Use the following flowchart and Figure 6-9 and Figure 6-10 as an aid in troubleshooting the main circuit board and the generator set. If the prescribed remedy does not correct the problem, replace the circuit board. The controller circuit board includes light emitting diodes (LEDs) indicating relay coil power and aids in circuit board and generator fault detection. When the K1, K2, K3, K4, or K5 relays receive power, the corresponding LED lights. The LED does not indicate whether the relay coil is energized. Determine if relay coil is energized, by analyzing the generator faults and performing a continuity test on the relay coil.



1. LED1
2. K1 relay (fault)
3. K3 relay (crank/run)
4. LED3
5. LED4
6. K4 relay (crank)
7. P1 connector
8. K2 relay (run)
9. LED2

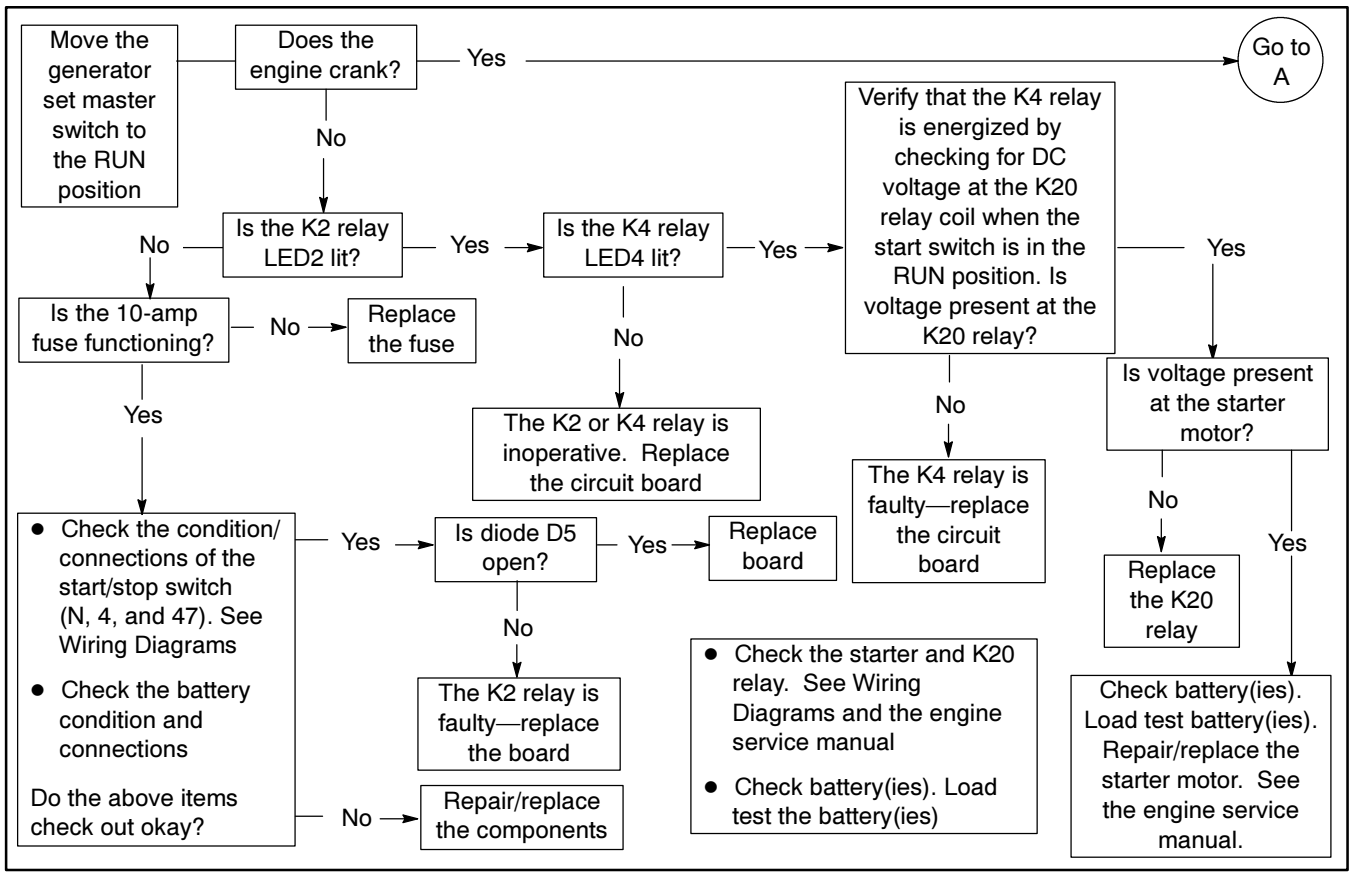
Figure 6-9 Relay Controller Circuit Board E-254717 (COZ/CFOZ Models)

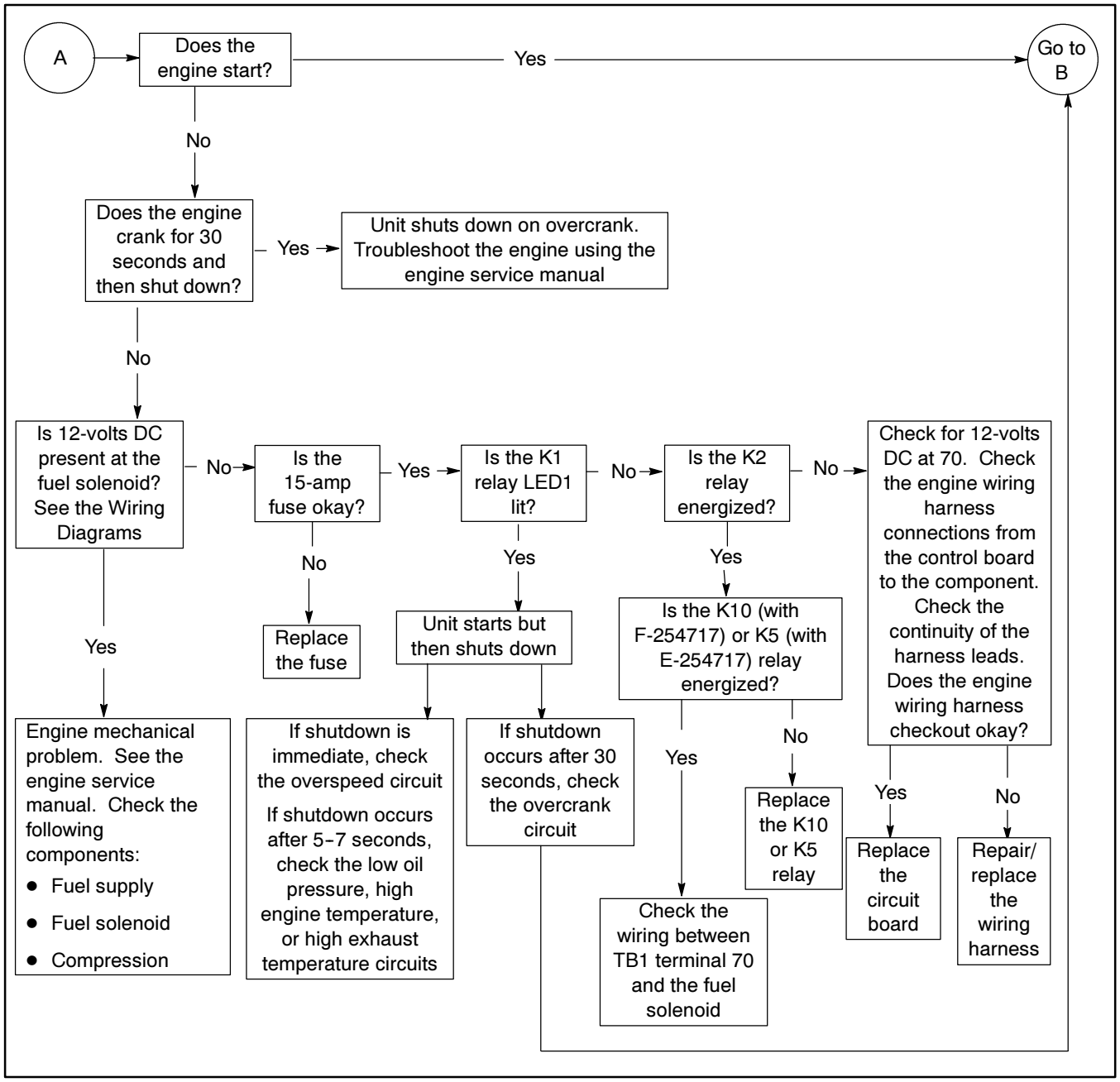


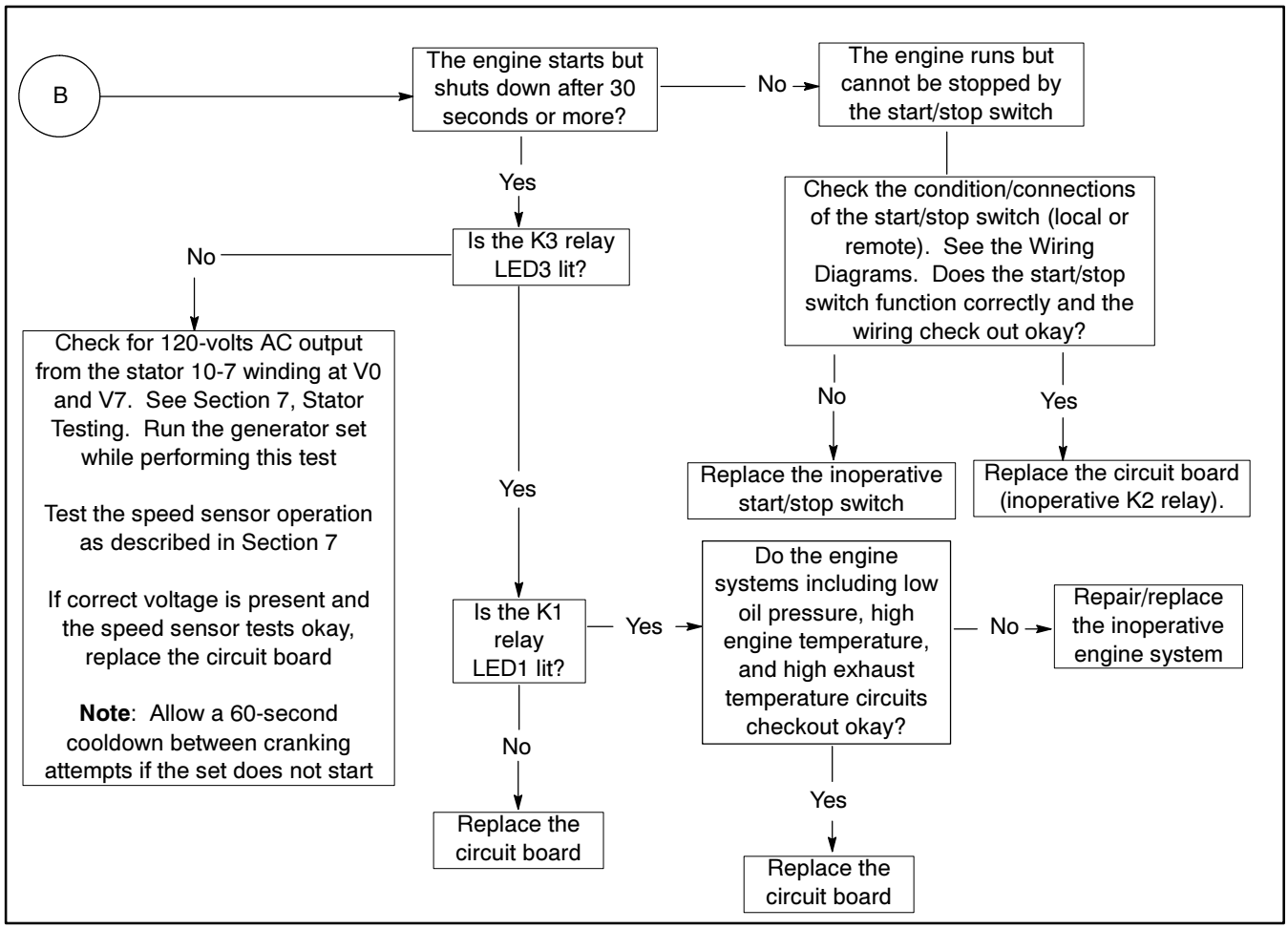
1. K5 relay (fault latch)
2. K1 relay (fault)
3. K3 relay (crank/run)
4. LED3
5. LED4
6. K4 relay (crank)
7. P1 connector
8. K2 relay (run)
9. LED2
10. LED1
11. LED5

Figure 6-10 Relay Controller Circuit Board F-254717 (EOZ/EFOZ Models)

6.2.1 Relay Controller Flowchart


Move the generator set master switch to the RUN position
Does the engine crank?
Yes
Go to A
No
Is the K2 relay LED2 lit?
No
Yes
Is the K4 relay LED4 lit?
Yes
Verify that the K4 relay is energized by checking for DC voltage at the K20 relay coil when the start switch is in the RUN position. Is voltage present at the K20 relay?
Yes
Is the 10-amp fuse functioning?
No
Replace the fuse
No
Is voltage present at the starter motor?
Yes
The K2 or K4 relay is inoperative. Replace the circuit board
No
The K4 relay is faulty—replace the circuit board
No
Yes
Replace the K20 relay
Yes
• Check the condition/ connections of the start/stop switch (N, 4, and 47). See Wiring Diagrams
• Check the battery condition and connections
Do the above items check out okay?
Yes
Is diode D5 open?
Yes
Replace board
No
The K2 relay is faulty—replace the board
No
Repair/replace the components
• Check the starter and K20 relay. See Wiring Diagrams and the engine service manual
• Check battery(ies). Load test the battery(ies)
Check battery(ies). Load test battery(ies). Repair/replace the starter motor. See the engine service manual.


A
Does the engine start?
Yes
Go to B
No
Does the engine crank for 30 seconds and then shut down?
Yes
Unit shuts down on overcrank. Troubleshoot the engine using the engine service manual
No
Is 12-volts DC present at the fuel solenoid? See the Wiring Diagrams
No
Is the 15-amp fuse okay?
Yes
Is the K1 relay LED1 lit?
No
Is the K2 relay energized?
No
Check for 12-volts DC at 70. Check the engine wiring harness connections from the control board to the component. Check the continuity of the harness leads. Does the engine wiring harness checkout okay?
Yes
Engine mechanical problem. See the engine service manual. Check the following components:
Fuel supply
Fuel solenoid
Compression
No
Replace the fuse
Yes
Unit starts but then shuts down
Yes
Is the K10 (with F-254717) or K5 (with E-254717) relay energized?
Yes
If shutdown is immediate, check the overspeed circuit
If shutdown occurs after 5–7 seconds, check the low oil pressure, high engine temperature, or high exhaust temperature circuits
If shutdown occurs after 30 seconds, check the overcrank circuit
Yes
Check the wiring between TB1 terminal 70 and the fuel solenoid
No
Replace the K10 or K5 relay
Yes
Replace the circuit board
No
Repair/ replace the wiring harness

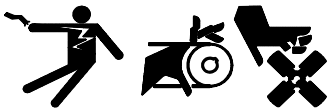

B
The engine starts but shuts down after 30 seconds or more?
No
The engine runs but cannot be stopped by the start/stop switch
Yes
Is the K3 relay LED3 lit?
No
Check the condition/connections of the start/stop switch (local or remote). See the Wiring Diagrams. Does the start/stop switch function correctly and the wiring check out okay?
No
Yes
Check for 120-volts AC output from the stator 10-7 winding at V0 and V7. See Section 7, Stator Testing. Run the generator set while performing this test
Test the speed sensor operation as described in Section 7
If correct voltage is present and the speed sensor tests okay, replace the circuit board
Note: Allow a 60-second cooldown between cranking attempts if the set does not start
Yes
Replace the inoperative start/stop switch
Replace the circuit board (inoperative K2 relay).
Is the K1 relay LED1 lit?
Yes
Do the engine systems including low oil pressure, high engine temperature, and high exhaust temperature circuits checkout okay?
No
Repair/replace the inoperative engine system
No
Yes
Replace the circuit board
Replace the circuit board

Notes

7.1 Generator Troubleshooting

Use the following flowchart to troubleshoot the generator set when detecting no or high voltage. The remaining parts of this section give additional and more detailed information about the individual checks/tests mentioned in the flowchart. Use the flowchart to initially isolate the possible problem.

⚠ WARNING

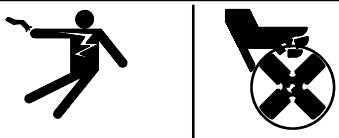


Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

⚠ WARNING



Hazardous voltage. Moving rotor.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocution is possible whenever electricity is present. Open the main circuit breakers of all power sources before servicing the equipment. Configure the installation to electrically ground the generator set, transfer switch, and related equipment and electrical circuits to comply with applicable codes and standards. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

Disconnecting the electrical load. Hazardous voltage can cause severe injury or death. Disconnect the generator set from the load by opening the line circuit breaker or by disconnecting the generator set output leads from the transfer switch and heavily taping the ends of the leads. High voltage transferred to the load during testing may cause personal injury and equipment damage. Do not use the safeguard circuit breaker in place of the line circuit breaker. The safeguard circuit breaker does not disconnect the generator set from the load.

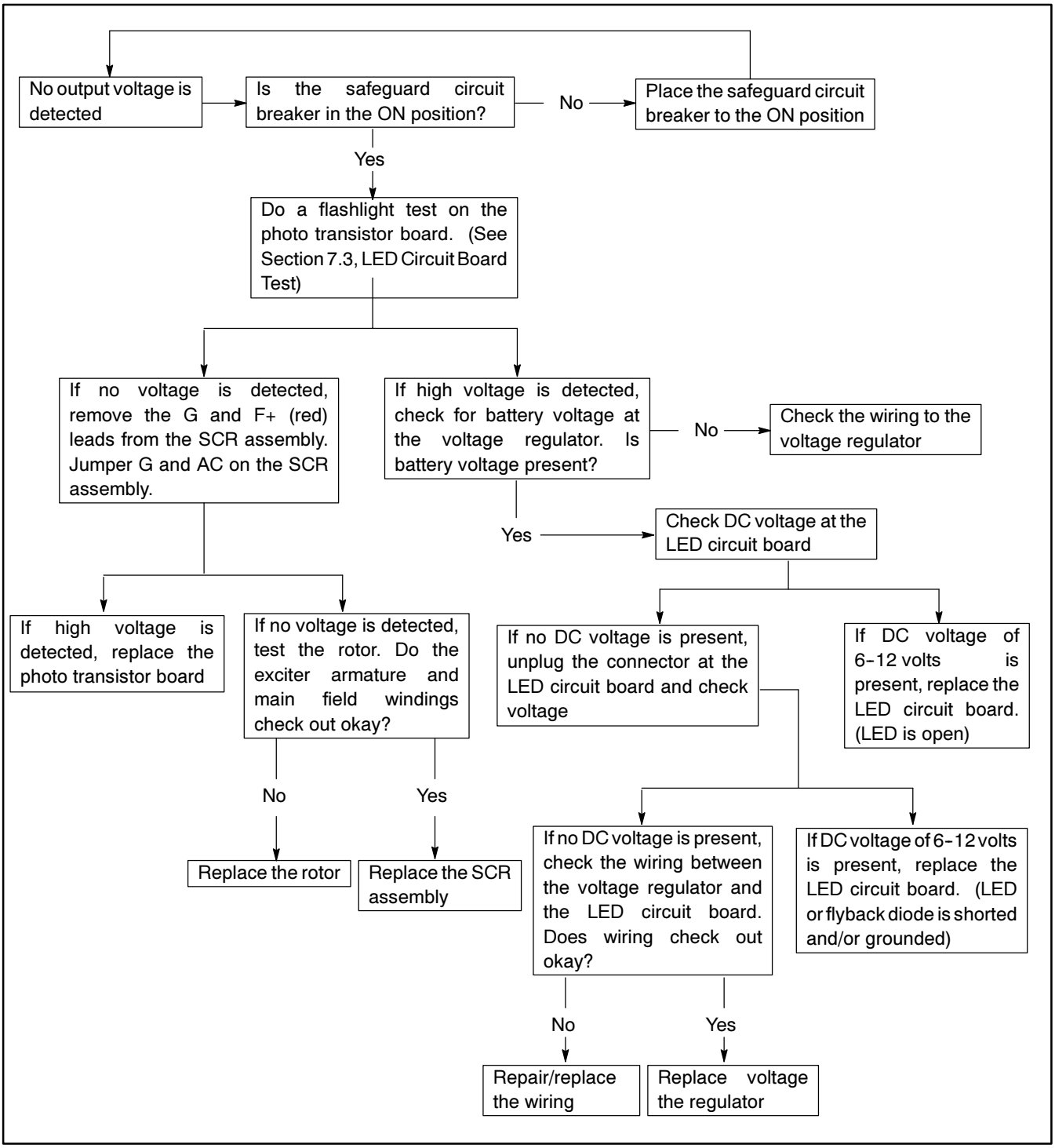

No output voltage is detected
Is the safeguard circuit breaker in the ON position?
No
Place the safeguard circuit breaker to the ON position
Yes
Do a flashlight test on the photo transistor board. (See Section 7.3, LED Circuit Board Test)
If no voltage is detected, remove the G and F+ (red) leads from the SCR assembly. Jumper G and AC on the SCR assembly.
If high voltage is detected, check for battery voltage at the voltage regulator. Is battery voltage present?
No
Check the wiring to the voltage regulator
Yes
Check DC voltage at the LED circuit board
If high voltage is detected, replace the photo transistor board
If no voltage is detected, test the rotor. Do the exciter armature and main field windings check out okay?
If no DC voltage is present, unplug the connector at the LED circuit board and check voltage
If DC voltage of 6-12 volts is present, replace the LED circuit board. (LED is open)
No
Yes
Replace the rotor
Replace the SCR assembly
If no DC voltage is present, check the wiring between the voltage regulator and the LED circuit board. Does wiring check out okay?
If DC voltage of 6-12 volts is present, replace the LED circuit board. (LED or flyback diode is shorted and/or grounded)
No
Yes
Repair/replace the wiring
Replace voltage the regulator

Figure 7-1 Troubleshooting Generator, No Output Voltage

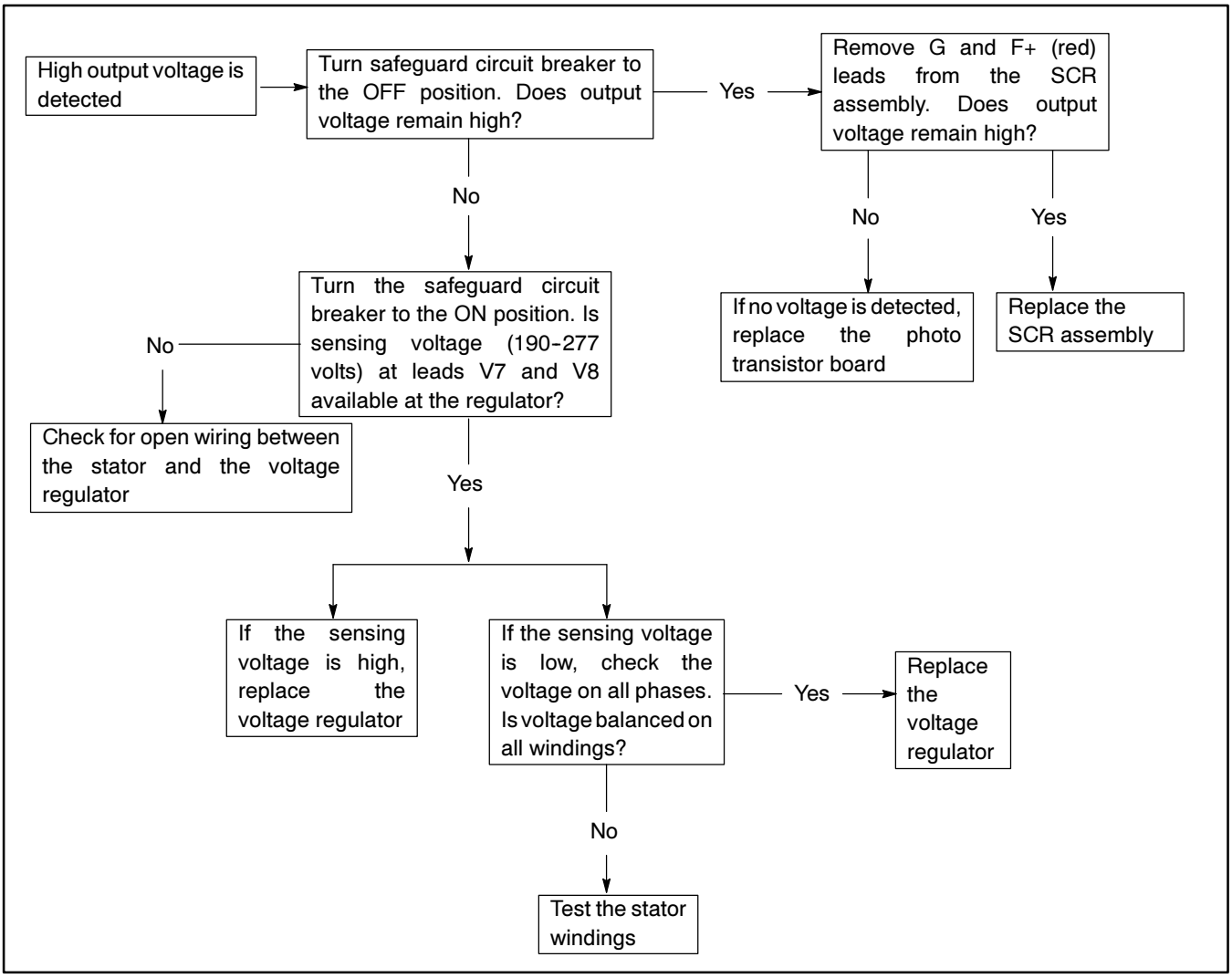
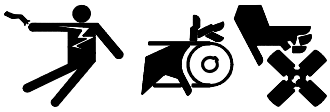

High output voltage is detected
Turn safeguard circuit breaker to the OFF position. Does output voltage remain high?
Yes
Remove G and F+ (red) leads from the SCR assembly. Does output voltage remain high?
No
Yes
No
If no voltage is detected, replace the photo transistor board
Replace the SCR assembly
Turn the safeguard circuit breaker to the ON position. Is sensing voltage (190-277 volts) at leads V7 and V8 available at the regulator?
No
Check for open wiring between the stator and the voltage regulator
Yes
If the sensing voltage is high, replace the voltage regulator
If the sensing voltage is low, check the voltage on all phases. Is voltage balanced on all windings?
Yes
Replace the voltage regulator
No
Test the stator windings

Figure 7-2 Troubleshooting Generator, High Output Voltage

⚠ WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

⚠ WARNING

Hazardous voltage. Moving rotor. Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Disconnecting the electrical load. Hazardous voltage can cause severe injury or death. Disconnect the generator set from the load by opening the line circuit breaker or by disconnecting the generator set output leads from the transfer switch and heavily taping the ends of the leads. High voltage transferred to the load during testing may cause personal injury and equipment damage. Do not use the safeguard circuit breaker in place of the line circuit breaker. The safeguard circuit breaker does not disconnect the generator set from the load.

Follow all safety precautions located in the front of this manual and the additional precautions found within the text. Figure 7-3 lists the various generator output conditions and component tests. Refer to Figure 7-4, AC Voltage Control for assistance in troubleshooting.

7.2 Generator Testing

This section covers generator testing for the following generator conditions:

- No output on any phase
- Overvoltage
- Fluctuating voltage

7.2.1 No Output On Any Phase

No Output On Any Phase Test Procedure

1. Check the safeguard breaker, if equipped. If the safeguard breaker is open, close the breaker and, with the set running, check the AC voltmeter for AC output voltage.
2. If AC output is not present, then:
   a. Check wire 1B from the safeguard breaker and wire 7N (ground) to the voltage regulator.
   b. Check for voltage to the safeguard breaker, if equipped.
3. If all items in step 2 are functioning, proceed to Section 7.3, LED Circuit Board Test, and Section 7.5, Automatic Voltage Regulator (AVR) Operation and Adjustment.
4. If tests indicate LED and AVR are functioning correctly, proceed with the test of the photo transistor board and SCR assembly (see Section 7.4). Otherwise, continue with the AVR test.
5. If the photo transistor board test indicates the board is functioning correctly, proceed to the exciter armature test as described later in Section 7.8.
6. If the exciter armature test indicates the armature is functioning correctly, proceed to the generator field test as described later in Section 7.7.
7. If the generator field test indicates the field is functioning correctly, replace the SCR assembly or the photo transistor board as described later in Section 7.4.

Components and Circuits to Test Under Certain Generator Output Conditions									
Generator Output Condition	LED Board	Photo Transistor Board	Automatic Voltage Regulator (AVR)	SCR Assembly	Safeguard Breaker	Exciter Armature	Generator Field	Generator Stator	Voltage Adjustment Pot
No Output	●	●	●	●	●	●	●	●	●*
Over Voltage		●†	●	●					
Fluctuating Voltage	●	●	●	●		●	●	●	

* No output voltage if voltage adjustment potentiometer circuit is open or shorted to ground.

† Overvoltage may occur if an outside light source is present when the LED board and cover are removed.

Figure 7-3 Troubleshooting Guide

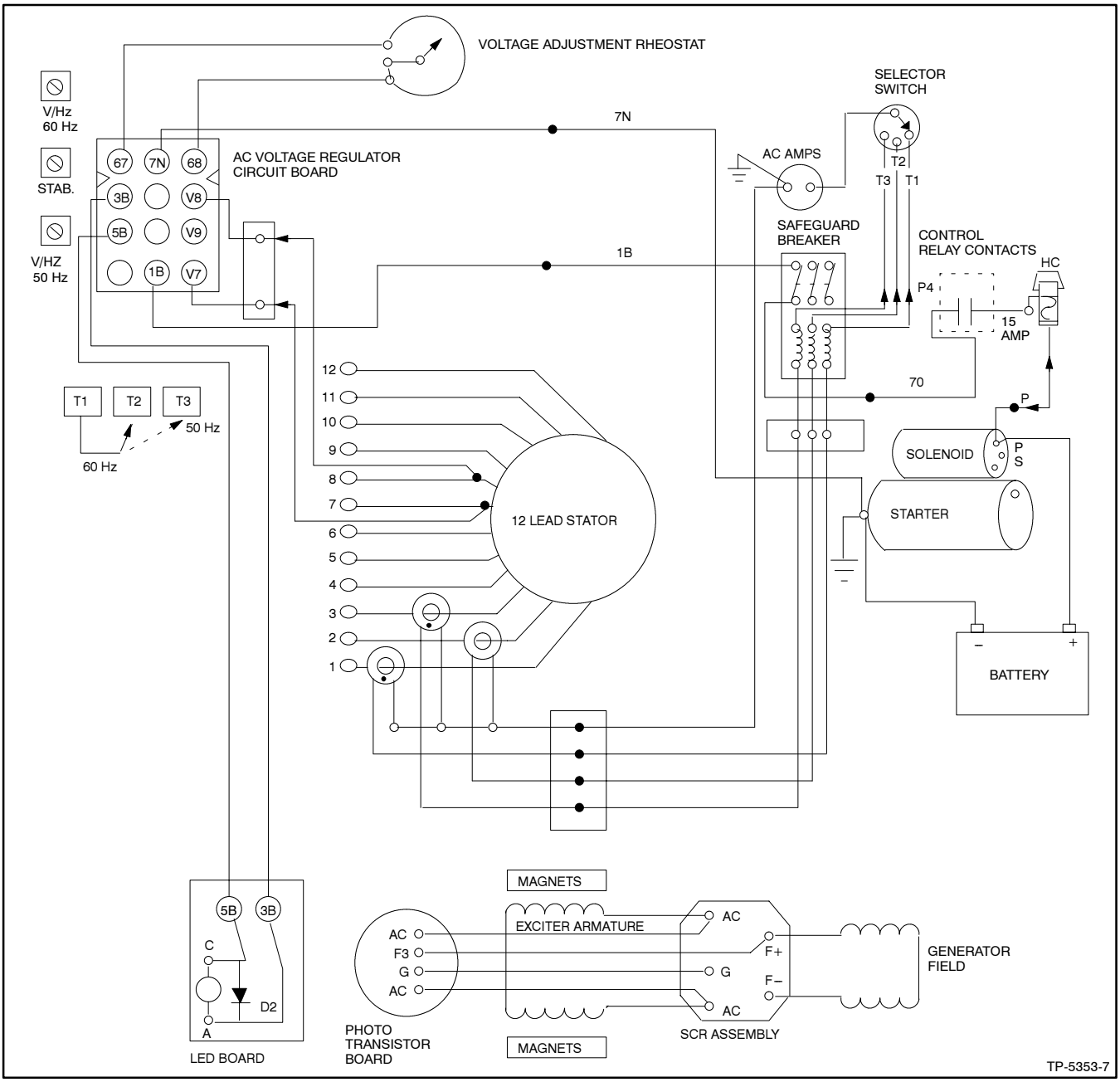


Figure 7-4 AC Voltage Control, Typical

7.2.2 Overvoltage

Overvoltage Test Procedure

Note: If overvoltage occurs, disconnect the harness plug at the voltage regulator. If overvoltage continues, the problem lies in the photo transistor circuit and/or SCR assembly; proceed through the following troubleshooting steps. If output voltage disappears, the problem is in the AVR, including connections and/or wiring.

1. Remove the LED board and cover.

2. Examine the photo transistor board for visible signs of damage (open foil patterns or heat discoloration). Replace the photo transistor board if it is visibly damaged. If overvoltage continues after replacement of the photo transistor board, proceed to step 3.

3. Remove the green (center) lead from the G terminal and the red lead from the F+ terminal of the SCR assembly. Tape each terminal end of leads to prevent contact with adjacent metal components.

4. With the safeguard breaker open, start the generator set. The lack of AC output indicates the SCR assembly is functioning properly. If overvoltage continues, replace the SCR assembly.

   Note: When replacing the SCR assembly do not exceed a torque value of 0.9 Nm (8 in. lbs.) when tightening the SCR mounting bolts.

5. If overvoltage is evident with the safeguard breaker closed, check for an open circuit in leads V7 and V8 to the AVR. If these circuits are open or shorted, repair or replace. Check the voltage rheostat circuit (leads 67 and 68). Repair or replace as necessary.

6. If all the circuits described in step 5 are functioning, check the AVR as described in Section 7.5.

7.2.3 Fluctuating Voltage

Fluctuating Voltage Test Procedure

1. Check the generator output leads for proper connections. See Section 9, Wiring Diagrams.

2. Check for loose connections to the AVR, LED board, photo transistor board, or SCR assembly.

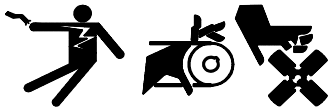
3. Check the stator for shorted or open windings; See Section 7.6, Stator.

4. Verify the AVR adjustment. See Section 7.5, Automatic Voltage Regulator Operation and Adjustment.

7.3 LED Circuit Board Test

The following procedure provides testing information for the LED circuit board. Certain steps require that the generator set be running. While the generator set is not running, disable the generator set. See the following safety precautions. Disconnect all load from the generator set during this test.

⚠ WARNING

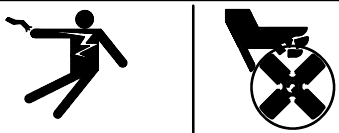


Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

⚠ WARNING



Hazardous voltage. Moving rotor.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Disconnecting the electrical load. Hazardous voltage can cause severe injury or death. Disconnect the generator set from the load by opening the line circuit breaker or by disconnecting the generator set output leads from the transfer switch and heavily taping the ends of the leads. High voltage transferred to the load during testing may cause personal injury and equipment damage. Do not use the safeguard circuit breaker in place of the line circuit breaker. The safeguard circuit breaker does not disconnect the generator set from the load.

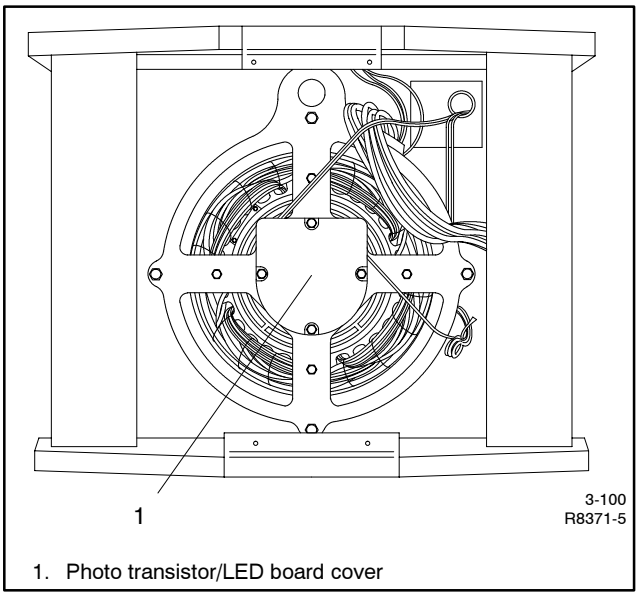
Testing the photo transistor circuit board. Hazardous voltage can cause severe injury or death. When the end cover is removed, do not expose the photo transistor circuit board mounted on the generator set end bracket to any external light source, as exposure to light causes high voltage. Keep foreign sources of light away from the photo transistor circuit board during testing. Place black electrical tape over the LED on the circuit board before starting the generator set.

LED Circuit Board Test

1. Remove the junction box panels from the generator end of the unit and remove the photo transistor board/LED board cover. See Figure 7-5.

2. With the generator set running at no load, shine a flashlight on the exposed photo transistor board. See Figure 7-6.

3. Observe the AC output voltmeter. The AC output voltage should be high. Switch the flashlight off or turn it away from the rotating photo transistor board. The AC output voltage should be low. If these conditions exist (high voltage while the photo transistor board is illuminated and low voltage while the photo transistor board is dark), then the photo transistor board and SCR assembly are functioning properly. The fault is likely in the wiring, AVR, or LED circuit board. If the generator does not respond this way to the flashlight test, the fault is probably in the photo transistor board (PCB assembly) or the SCR assembly. Proceed to the tests for these items.



1. Photo transistor/LED board cover

Figure 7-5 Panels Removed

4. With the generator set running, observe approximately 1–2 volts DC at 3B (+) and 5B (–) at the LED board. See Figure 7-7. Shine the flashlight on the photo transistor. DC voltage reading should drop, showing the AVR is functioning properly. If voltages are not observed, refer to the AVR test.

5. Stop the generator set.

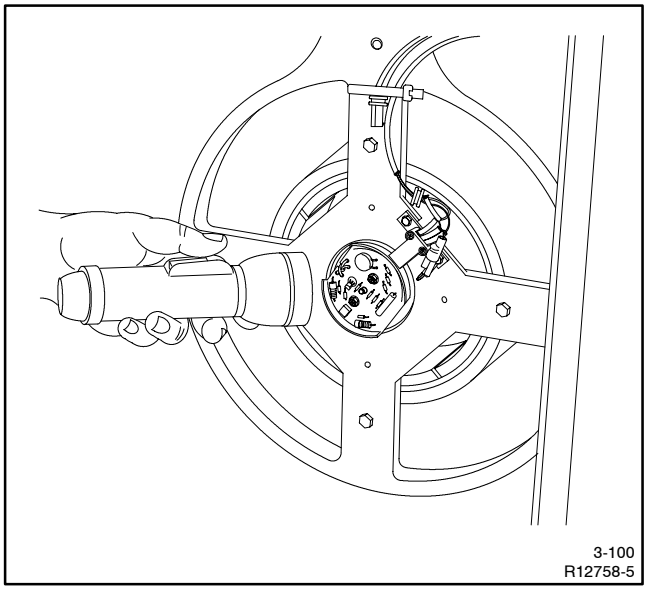


Figure 7-6 LED Flashlight Test

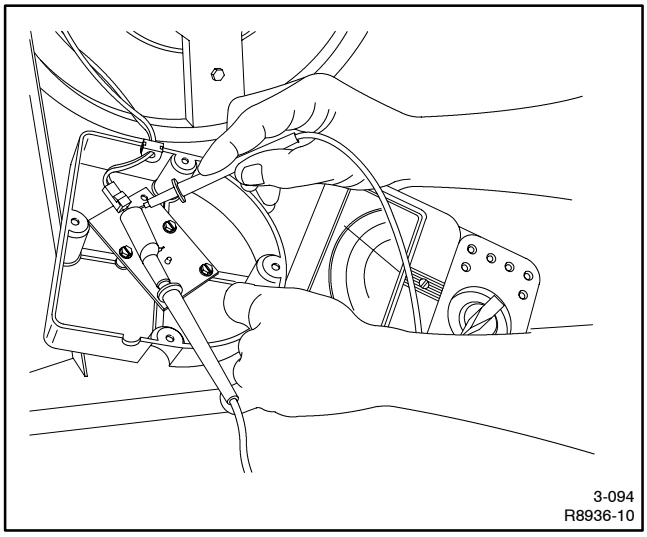


Figure 7-7 Checking LED Board

7.4 SCR Assembly and Photo Transistor Board

7.4.1 Concept and Equipment

The SCR assembly mounts behind the exciter armature and controls current flow to the generator field. The command and sensing circuitry mounts on the shaft-mounted photo transistor board. See Figure 7-8. The generator set only functions if both components are functional. The following test determines which component is faulty. Because the end bracket must be removed from the set to correctly test these components, do not begin this procedure unless there is reasonable certainty that these components are inoperative. See Section 7.1, Generator Troubleshooting. Examine the photo transistor board for visible signs of damage (open foil patterns and heat discoloration) before removing the entire SCR assembly for testing. See Section 7.9, End Bracket Removal and Replacement, and Section 8, Disassembly/ Reassembly, for end bracket removal.

Testing the SCR assembly and photo transistor board requires the following components:

- Light bulb with socket, one 120-volt/110-watt.
- Switch, double-pole/single-throw (DPST), 120-volt 10-amp minimum.
- Fuse, 1 amp, in holder.
- Plug with cord, 120-volt AC.
- SCR assembly and photo transistor board (one must be functioning)

7.4.2 SCR Assembly and Photo Transistor Board Test

This test simulates the normal operation of the components when the generator is running. In the test, a *known* working component (example: photo transistor board) is matched with a component of unknown quality (example: SCR assembly). If the components do not function normally during the test, the component of unknown quality may be inoperative. Test either component in this manner.

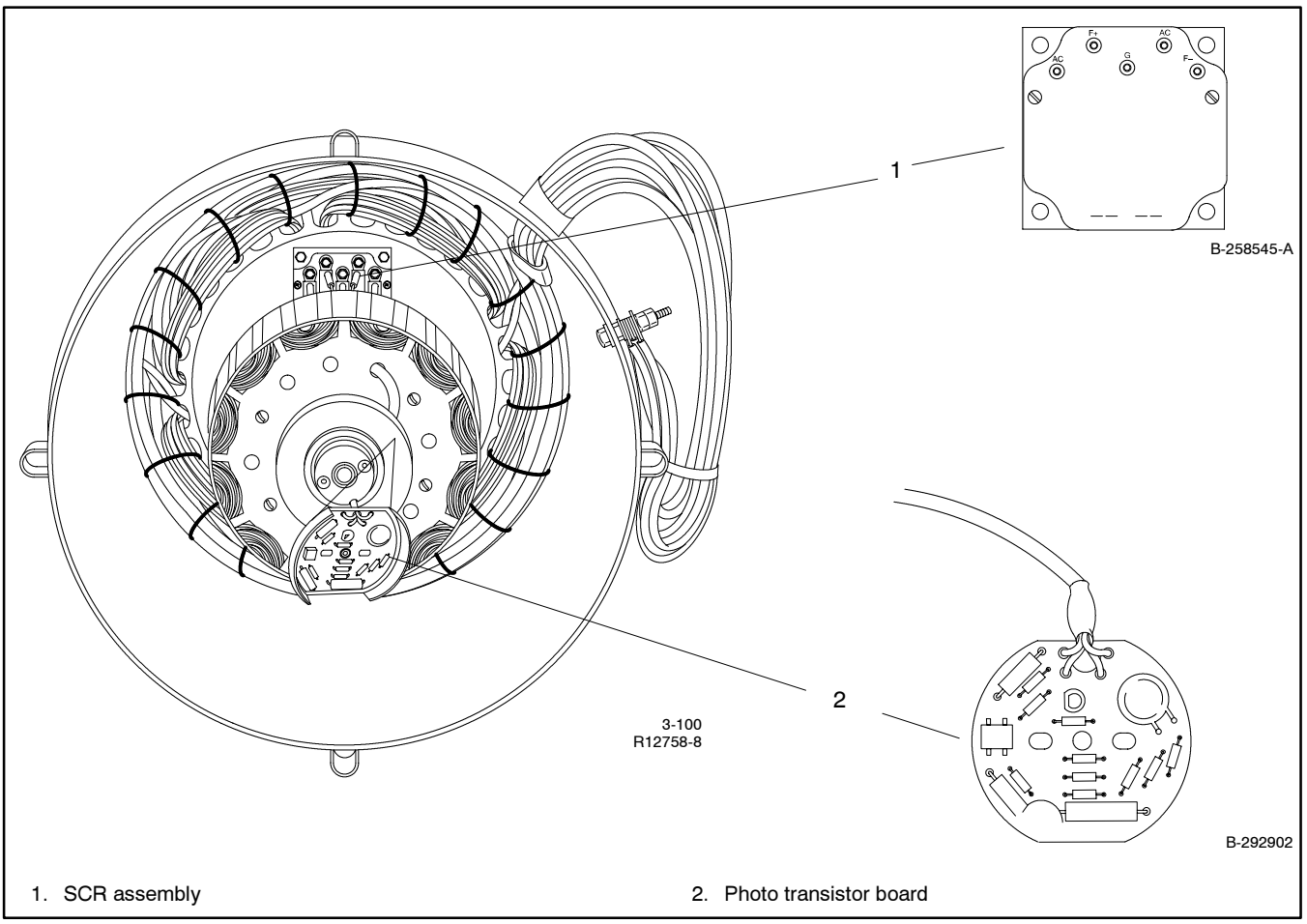


Figure 7-8 Component Locations

⚠ WARNING

Hazardous voltage. Moving rotor. Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Hazardous voltage can cause severe injury or death. Carefully follow instructions in the equipment manual when testing or servicing generator set in the presence of voltage.

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocution is possible whenever electricity is present. Open the main circuit breakers of all power sources before servicing the equipment. Configure the installation to electrically ground the generator set, transfer switch, and related equipment and electrical circuits to comply with applicable codes and standards. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

SCR Assembly and Photo Transistor Board Test

1. Connect the components as illustrated in Figure 7-9. If testing the photo transistor board, the SCR assembly must be *working*. If testing the SCR assembly, the photo transistor board must be *working*.

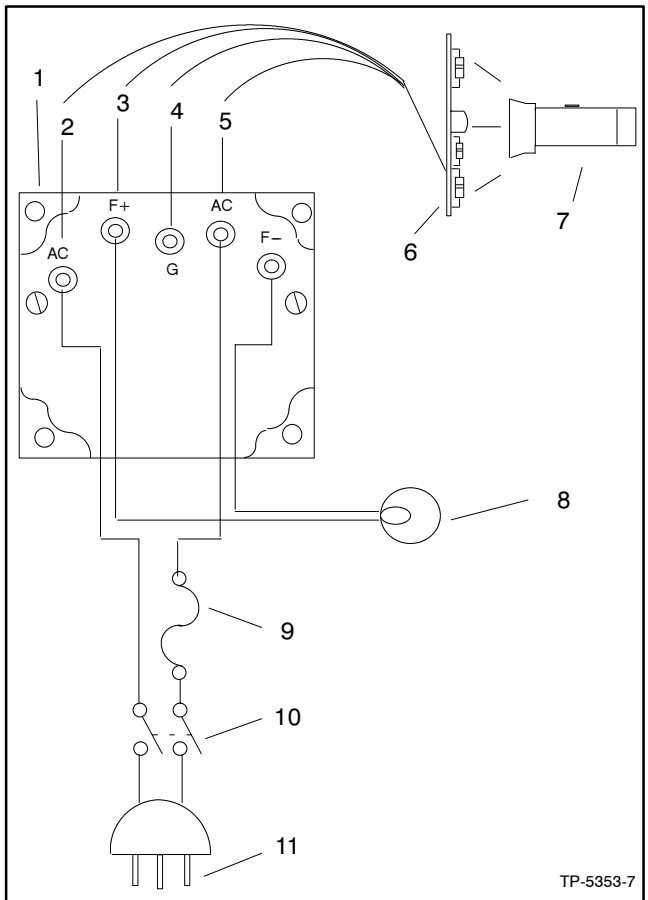
   Note: When testing the SCR assembly, secure all connections with nuts to ensure good contact between the wire terminals and the foil pattern. The threaded studs are insulated from the foil pattern and are not in contact except when secured by a nut. Do not exceed 1.4 Nm (12 in. lbs.) when tightening SCR assembly nuts.

2. With the cord switch in the OFF position, plug in the electrical cord.

3. Turn the cord switch to the ON position.

4. Shield the photo transistor board from all other light sources during this test. Direct the test light to the photo transistor board. If both components are working, the test fixture light bulb lights when the external light source is applied to the photo transistor board. Remove the light source; the fixture light bulb should go out. If the test fixture light bulb does not light or is lit prior to receiving the external light source, the tested component is inoperative (in this example the SCR). Replace the SCR assembly.

   Note: When replacing the SCR assembly, do not exceed a torque value of 0.9 Nm (8 in. lbs.) when tightening the SCR mounting bolts.

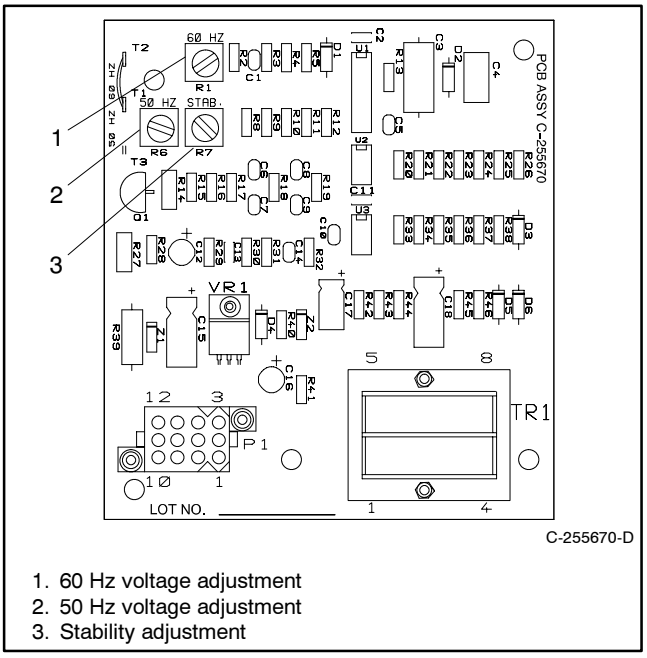


1. SCR assembly
2. White wire
3. Red wire
4. Green wire
5. Black wire
6. Photo transistor board
7. Light source (flashlight)
8. 120-volt/100-watt lamp
9. Fuse (1 amp)
10. Switch (DPST) S1
11. 120 volts AC

Figure 7-9 SCR Assembly and Photo Transistor Board

7.5 Automatic Voltage Regulator (AVR) Operation and Adjustment

The AVR monitors output voltage amplitude and frequency to supply current to the stationary LED board. The AVR circuit board includes volts/Hz and stability adjustment potentiometers. The factory sets the volts/Hz adjustment and normally requires no further adjustment. If replacement of the controller circuit board or operation of the generator under extreme loads results in voltage instability, adjust the potentiometers according to the procedure following. See Figure 7-10.



1. 60 Hz voltage adjustment
2. 50 Hz voltage adjustment
3. Stability adjustment

Figure 7-10 AVR Adjustment

Stability Potentiometer. Fine tunes the voltage regulator to reduce light flicker.

Volt/Hz Potentiometer. This adjustment determines engine speed (Hz) at which the generator output voltage begins to drop.

Voltage Regulator Adjustment

1. Place the generator set master switch in the OFF/RESET position.
2. Set the stability potentiometer to the far counterclockwise position.
3. Connect a 100-watt light bulb across terminals V0 and V7 on the controller terminal strip or across the terminals on the controller frequency meter.
4. Start the generator set. With the generator running at no load, observe light bulb flicker. Excessive light bulb flicker indicates poor stability.
5. Adjust the stability potentiometer until minimum flicker is obtained.
6. Use the controller voltage adjustment potentiometer (or remote voltage adjustment potentiometer) to make adjustments to the generator while running under normal load, if required.
7. Adjust the engine speed to the desired cut-in frequency. Factory setting is 57.5–58.0 Hz for 60 Hz models or 47.5–48.0 Hz for 50 Hz models as measured on the frequency meter. See Section 7.14, Governor Adjustment, for more information on engine adjustment.
8. Rotate the Volts/Hz adjustment potentiometer counterclockwise until the voltage level begins to drop (as measured on the voltmeter). When set to these specifications, the generator attempts to maintain normal output until the engine speed drops below the frequency set in the previous step (as load is applied).
9. Adjust the engine speed to the appropriate operating point. See Section 7.14.
10. Use the controller voltage adjustment potentiometer (or remote voltage adjustment potentiometer) to make final adjustments to the generator while running under normal load.
11. Readjust the stability potentiometer, if necessary.
12. Check the AVR's function by reducing the engine speed (Hz) and watching for a corresponding drop in AC voltage.

    At 60 Hz operation, AC voltage remains constant until the engine speed drops below 58 Hz (approximately). If AC frequency drops below 58 Hz, AC voltage declines.

    At 50 Hz operation, AC voltage remains constant until the engine speed drops to 48 Hz (approximately). If AC frequency drops below 48 Hz, AC voltage declines.

    If the AVR does not function as described above, refer to the following test for the cause of the malfunction.

Voltage Regulator Test

1. Close the safeguard breaker, if equipped.

2. Disconnect the wiring harness connector from the voltage regulator and check for continuity between the voltage sensing leads V7 and V8 (pins 4 and 10). See Figure 7-11. If the circuit between V7 and V8 is open, repair or replace it. An open circuit normally results in a high voltage or overvoltage condition.

3. Check the 15-amp fuse, if equipped.

4. If continuity exists between V7 and V8, check for continuity in the voltage adjustment circuit (leads 67 and 68). Disconnect the voltage regulator harness plug and check for resistance between pins 1 and 3. Measured resistance should change as the voltage adjust rheostat is turned. Repair or replace inoperative components as necessary.

   Note: An inoperative voltage adjust rheostat usually results in a nonadjustable voltage.

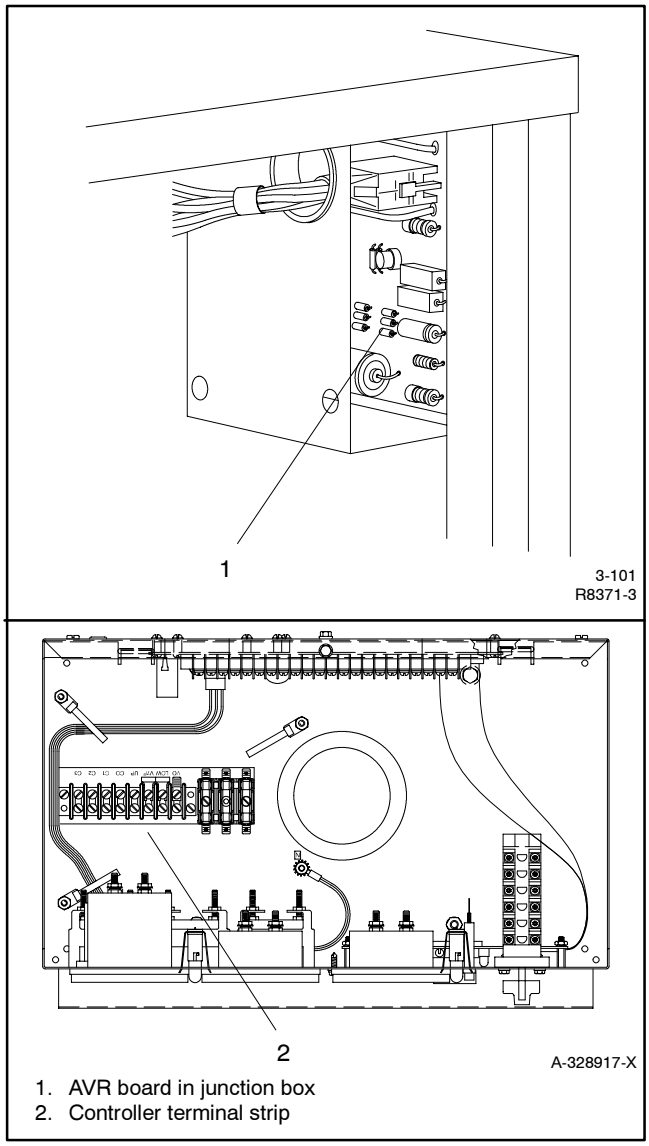
5. Check the 15-amp fuse, if equipped, inside the controller. If this circuit is open, repair or replace the inoperative components and/or wiring.

6. Check for battery voltage at the voltage regulator harness plug (pins 2 and 11) with the generator set running. If there is no battery voltage between pins 2 and 11, check the safeguard circuit breaker.

   Note: Lack of battery voltage to the voltage regulator usually results in very low voltage at the main output leads.

7. While the generator set is running, check for approximately 1–2 volts DC output between terminals 3B (+) and 5B (–) on the LED board or disconnect the 3B/5B connector at the LED board and check for 8 volts DC (approximately) at the connector. If there is no DC voltage output present between 3B and 5B, check for an open or short circuit in the wiring back to the voltage regulator. If a fault exists in the voltage regulator wiring, repair or replace as necessary. If the voltage regulator wiring appears functional, replace the voltage regulator.

   Note: Low or no voltage at the LED circuit board may cause a low output voltage fault.



1. AVR board in junction box
2. Controller terminal strip

Figure 7-11 AVR and Connections

7.6 Stator

Note: When replacing the rotor or stator, use a skewed (slanted) rotor with a straight stator per original manufacturer.

Stator Test Procedure

1. Check the generator output leads for proper connections. See Section 9, Wiring Diagrams.

2. Check the stator windings for:

   a. Shorted windings: Replace the stator if burnt or hot windings exist. See Figure 7-12.

      Note: Disconnect V7, V8, V9, and V0 leads at the controller AC fuse terminal blocks before performing the open winding test.

   b. Open windings: With an ohmmeter, check *each pair* of leads for low resistance readings (continuity). High resistance across A or low resistance (continuity) across B and ground indicates a faulty stator; if so, replace the stator. See Figure 7-13.

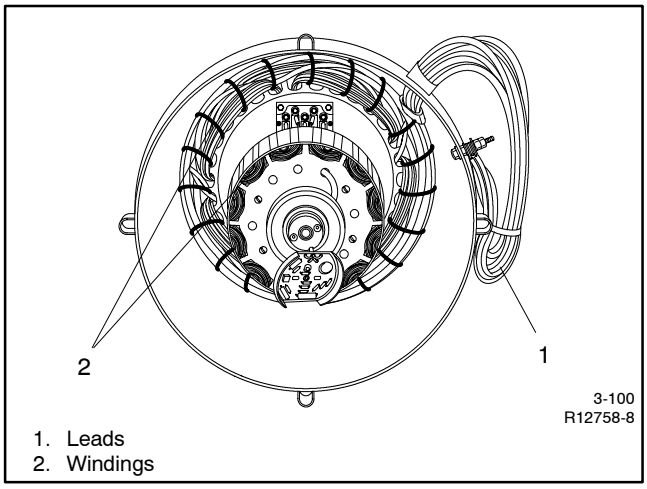


Figure 7-12 Stator

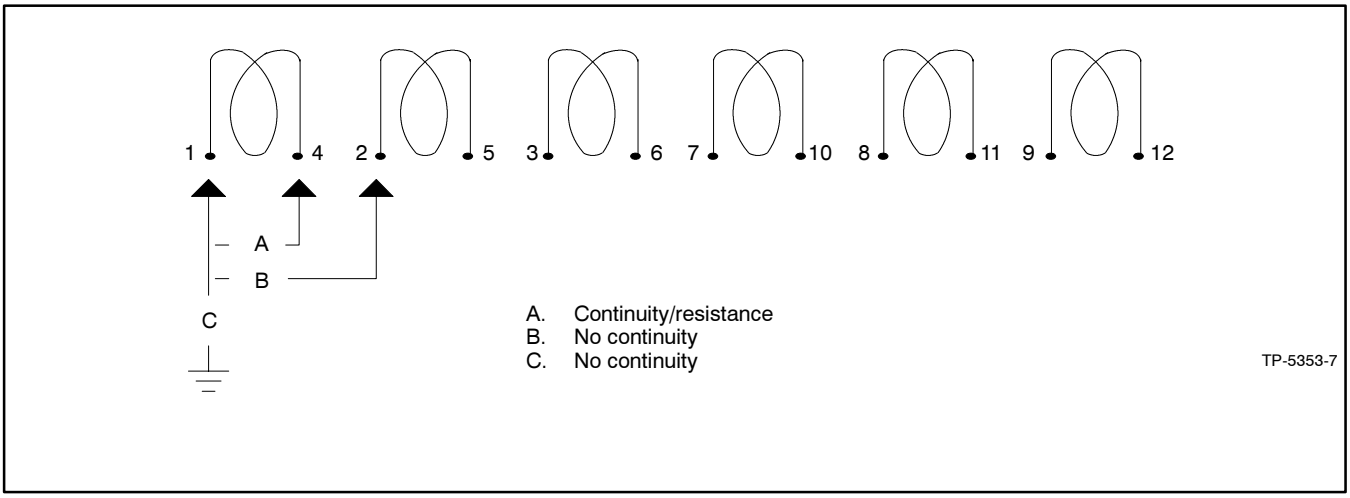
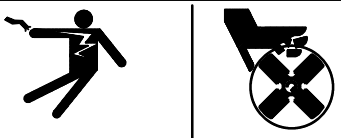


Figure 7-13 Stator Winding Test

7.7 Generator Field

⚠ WARNING



Hazardous voltage. Moving rotor. Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

High voltage test. Hazardous voltage can cause severe injury or death. Follow the instructions of the test equipment manufacturer when performing high-voltage tests on the rotor or stator. An improper test procedure can damage equipment or lead to generator set failure.

⚠ WARNING

Hot engine and exhaust system. Can cause severe injury or death.

Do not work on the generator set until it cools.

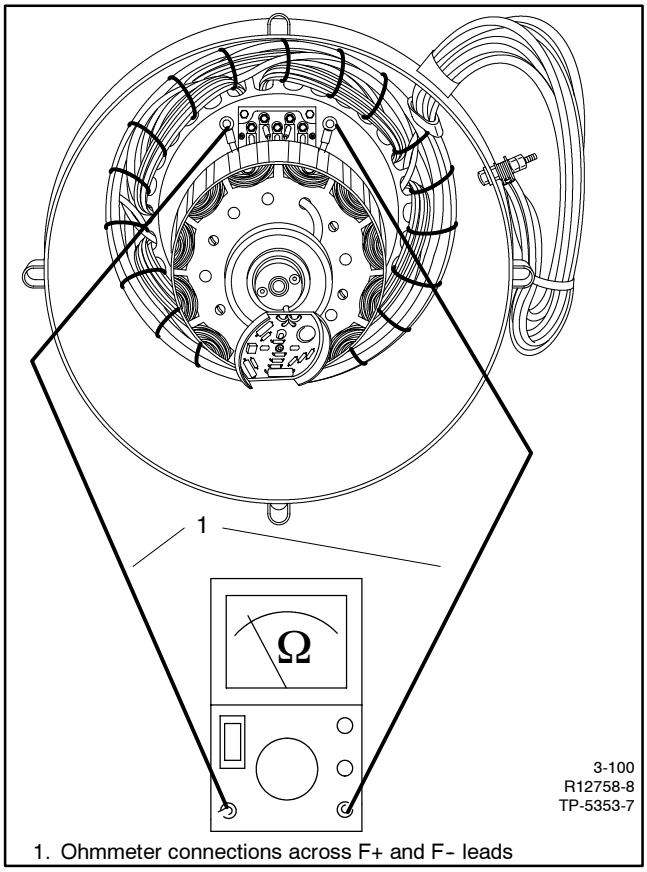
Servicing the generator. Hot parts can cause severe injury or death. Avoid touching the generator set field or exciter armature. When shorted, the generator set field and exciter armature become hot enough to cause severe burns.

Generator Field Test

1. Disconnect the generator set engine starting battery, negative (–) lead first.
2. Remove the end bracket. See Section 7.9, End Bracket Removal and Replacement, and Section 8, Disassembly/Reassembly.
3. Disconnect F+ and F– from the SCR assembly.
4. With an ohmmeter, check for continuity across the F+ and F– leads (see Figure 7-14). Resistance readings are shown in Section 1, Specifications, Generator.
5. Check for a grounded generator field. No continuity should exist between the field leads and the rotor assembly.
6. Using a megohmmeter, apply 500 volts DC to the F+ or F– lead and the rotor shaft. See Figure 7-15. Follow the instructions of the megohmmeter manufacturer when performing this test. A reading of approximately 5–7 kOhms and higher indicates the field winding is functional. A reading of less than 5–7 kOhms (approximately) indicates deterioration of the winding insulation and possible current flow to ground.
7. Repair or replace the rotor assembly.

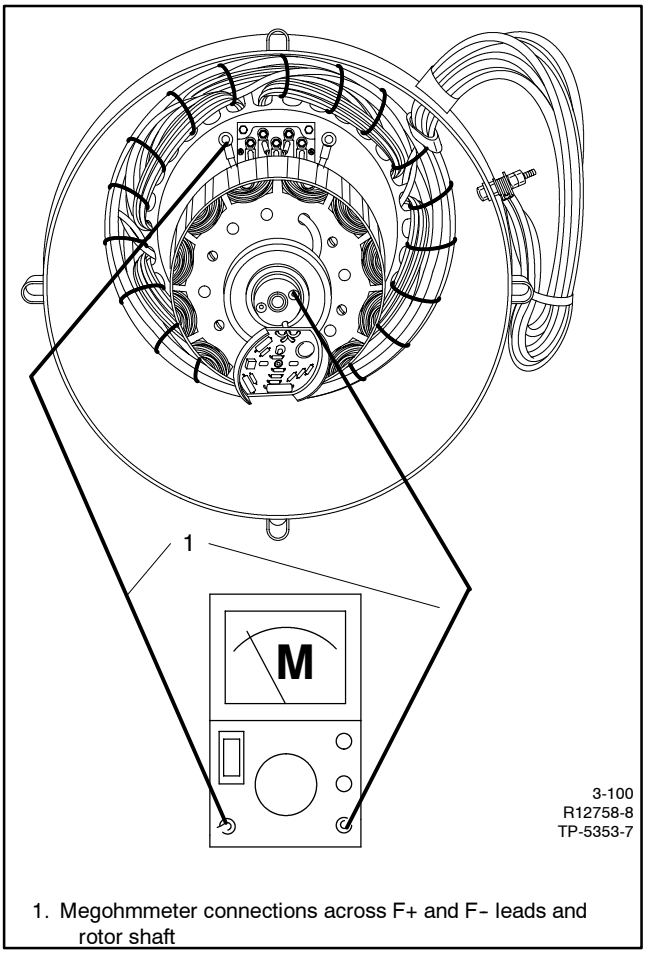
   Repair the F+ and F– leads if this test shows the leads are shorted to ground. If using splices, solder and insulate the splices. Use new sleeving when tying the leads to the shaft or the heat sink.

   Replace the generator rotor assembly if this test shows a shorted or grounded winding.



1. Ohmmeter connections across F+ and F– leads

Figure 7-14 Field Continuity Check

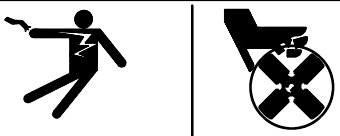


1. Megohmmeter connections across F+ and F– leads and rotor shaft

Figure 7-15 High Voltage Test

7.8 Exciter Armature

⚠ WARNING



Hazardous voltage. Moving rotor. Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

High voltage test. Hazardous voltage can cause severe injury or death. Follow the instructions of the test equipment manufacturer when performing high-voltage tests on the rotor or stator. An improper test procedure can damage equipment or lead to generator set failure.

⚠ WARNING

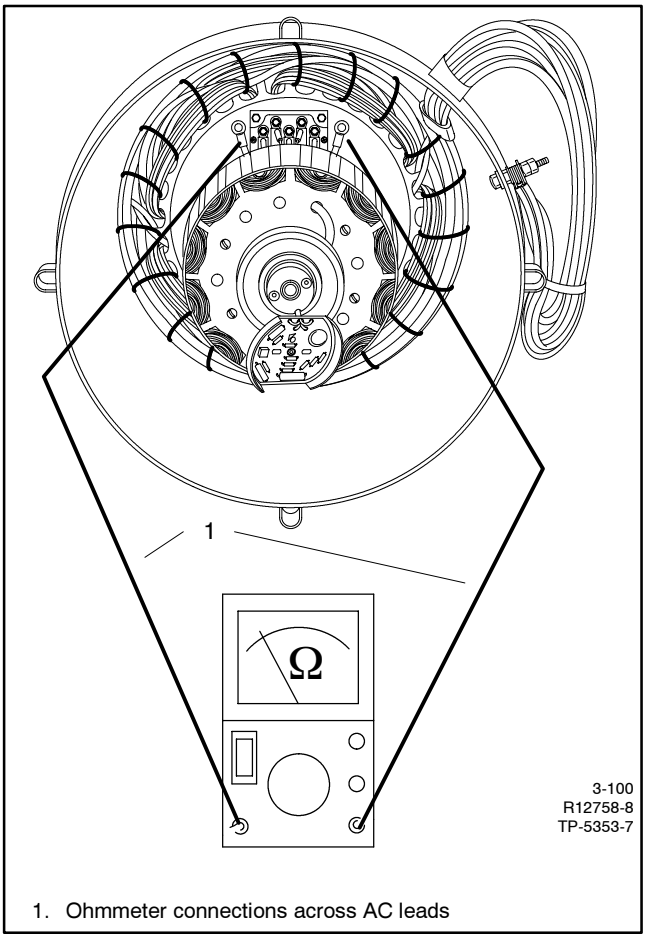
Hot engine and exhaust system. Can cause severe injury or death.

Do not work on the generator set until it cools.

Servicing the generator. Hot parts can cause severe injury or death. Avoid touching the generator set field or exciter armature. When shorted, the generator set field and exciter armature become hot enough to cause severe burns.

Exciter Armature Test

1. Disconnect the generator set engine starting battery, negative (–) lead first.
2. Remove the end bracket. See Section 7.9, End Bracket Removal and Replacement and Section 8, Disassembly/Reassembly for end bracket removal.
3. Disconnect the AC leads from the SCR assembly.
4. With an ohmmeter, check for continuity across the AC leads. See Figure 7-16.
5. Repair the AC leads if they are damaged or open. Solder and insulate any splices used. Use new sleeving when tying the leads to the shaft or the heat sink.
6. Visually check the exciter armature for shorted winding(s); with an ohmmeter check for low resistance readings. See Section 1, Specifications, Generator, for designed resistance readings. See Figure 7-16. Low resistance readings indicate a faulty exciter armature requiring replacement of the rotor assembly.



1. Ohmmeter connections across AC leads

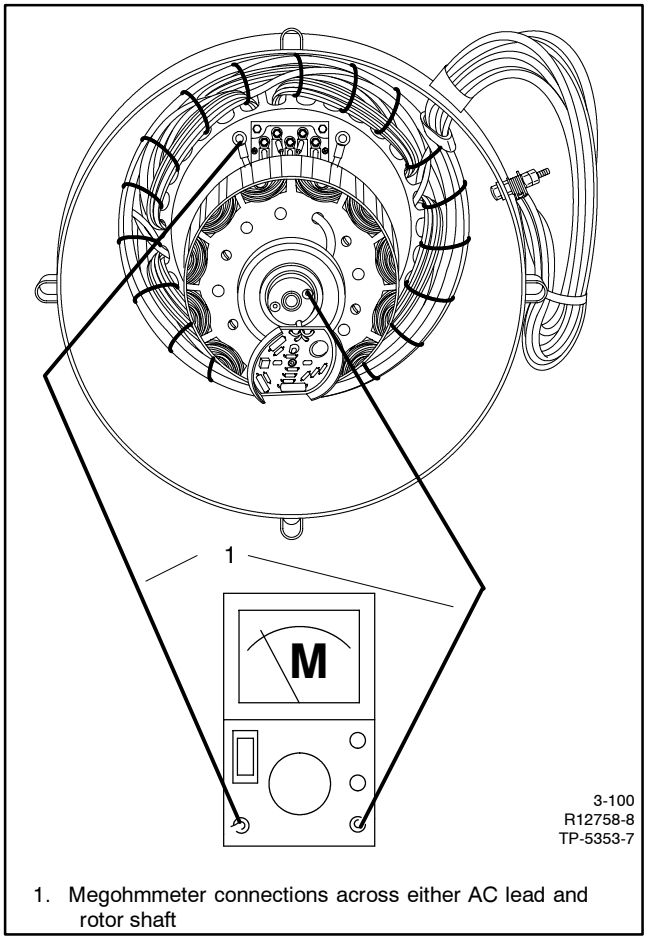
Figure 7-16 Exciter Armature Continuity Check

7. Using a megohmmeter, apply 500 volts DC to the rotor shaft and either AC lead. See Figure 7-17. Follow the instructions of the megohmmeter manufacturer when performing this test. A reading of approximately 5–7 kOhms and higher indicates the field winding is functional. A reading of less than 5–7 kOhms (approximately) indicates deterioration of the winding insulation and possible current flow to ground.

8. Repair or replace the rotor.

   Repair the AC leads if this test indicates the leads are shorted to ground. Solder and insulate any splices used. Use new sleeving when tying the leads to the shaft or the heat sink.

   Replace the rotor assembly if this test shows the armature is shorted to ground.



1. Megohmmeter connections across either AC lead and rotor shaft

Figure 7-17 Exciter Armature High Voltage Test

7.9 End Bracket Removal and Replacement

See Section 8, Disassembly/Reassembly for more information.

Note: Loosen the generator junction box before removing the end bracket. Remove the six junction box mounting screws and pull the junction box away from the engine to remove the end bracket.

End Bracket Removal

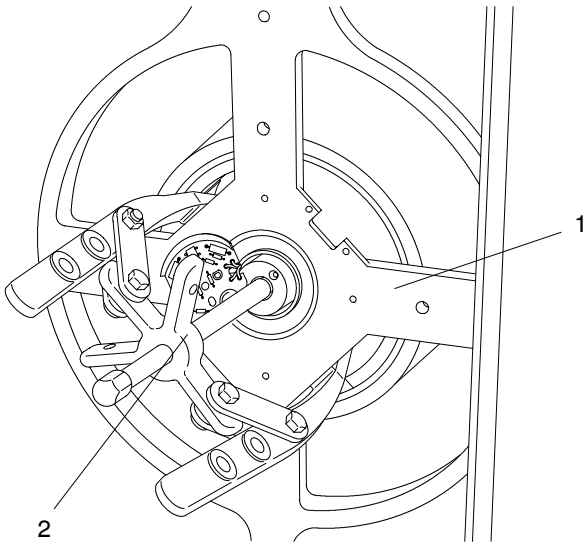
1. Remove the LED board and cover.
2. Disconnect the leads from the speed sensor.
3. Remove the screws holding the actuator cup and the photo transistor board.
4. Reach inside the stator shell and disconnect the photo transistor board leads from the SCR assembly to allow for slack when removing the end bracket.
5. Remove the four bolts holding the end bracket to the stator.
6. Use a puller tool to remove the end bracket. See Figure 7-18.

   Note: To avoid loosening the exciter field magnets, do not attempt to remove the end bracket by pounding it with a hammer.

7. Pull the end bracket and exciter field assembly over the exciter armature. Do not damage the exciter field magnets or photo transistor board.

End Bracket Replacement

Reverse the order of the disassembly to reinstall the end bracket/exciter field assembly.



1. End bracket
2. Puller tool

Figure 7-18 Removing End Bracket

7.10 Speed Sensor Test

The following procedure determines if the speed sensor (overspeed fault) is emitting a signal.

Speed Sensor Signal Test

1. With the generator set master switch in the OFF/RESET position, connect a DC voltmeter between the positive (+) lead (wire 24) at the speed sensor and the ground (wire 2). The voltmeter should indicate approximately 8–10 volts DC.

2. With the generator set running, connect the DC voltmeter negative probe to the 0 terminal (wire 16—white) on the speed sensor. Place the voltmeter positive probe on the positive (+) terminal (wire 24—red). The voltmeter should indicate approximately 12 volts DC.

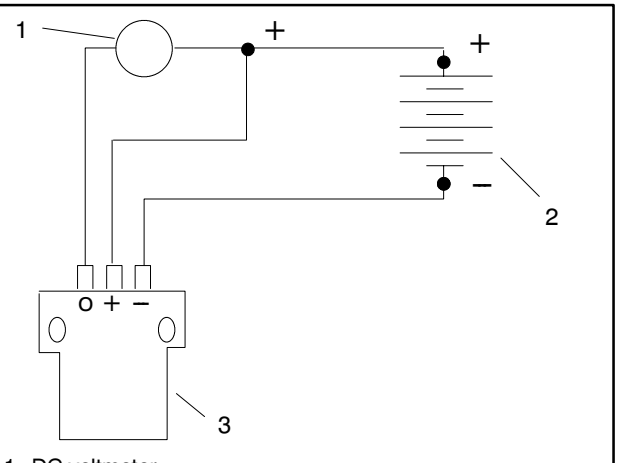
   Note: During the test the controller leads must remain connected to the speed sensor terminals. Slide the leads from the speed sensor terminals only enough to expose the connection for the test leads. Do not disconnect the leads.

If the speed sensor emits a signal, check the continuity of the speed sensor leads (wires 2, 16, and 24) between the controller P1 connector and the lead terminals at the speed sensor.

If the speed sensor does not emit a signal, test the speed sensor through the following procedure.

Speed Sensor Test

1. Connect the speed sensor, voltmeter, and DC voltage source as shown in Figure 7-19.



1. DC voltmeter
2. 12-volt battery or DC power supply
3. Speed sensor

Figure 7-19 Speed Sensor Test

2. Touch the sensing surface with a flat piece of iron or steel at least 4.1 cm (1/4 cubic inch) in size. The voltmeter test reading should equal the source voltage.

3. Remove the iron or steel from the sensing surface. Observe no test voltmeter reading.

7.11 Current Transformers

7.11.1 Function and Application

Current transformers provide several generator set functions including signal/drive for:

- Controller AC voltmeter/ammeter
- Safeguard circuit breaker
- Reactive droop compensator.

Generator set models do not have current transformers when they do not include the above items. The meters and safeguard circuit breaker share the same current transformer while the reactive droop compensator uses a separate current transformer. See Figure 7-20. The generator set junction box contains the stator leads and the current transformers.

When replacing the current transformer or stator assembly, install the current transformer according to the generator reconnection decal on the generator set, or see Section 9, Wiring Diagrams. Observe the correct current transformer position when installing the stator leads. The current transformer dot or HI mark position and the stator lead direction are essential for correct component function.

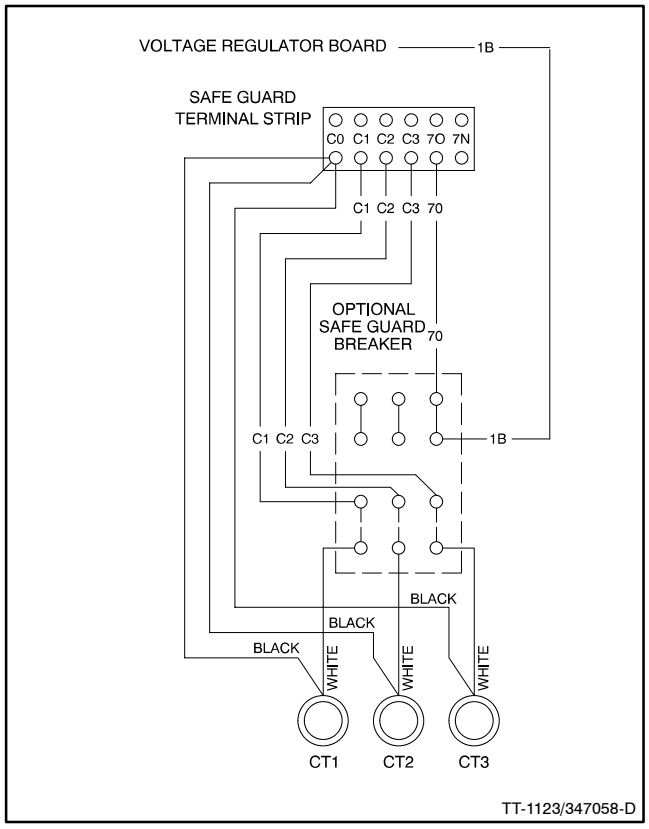


Figure 7-20 Current Transformers

A current transformer contains a coil of wire that induces a secondary voltage/current from the primary or stator lead passing through the center. The number of coil turns inside the current transformer determines the ratio. Replacement current transformers must have the same ratio as the original.

7.11.2 Testing

Use an ohmmeter to check the current transformer. Perform this test with the current transformer disconnected from the generator set. A resistance reading of infinity or 0 ohms suggests an open or shorted current transformer that needs replacement. Consider any other resistance reading acceptable.

7.12 Reactive Droop Compensator

7.12.1 Function and Application

The reactive droop compensator kit distributes the generator set load evenly between two generator sets in parallel. If the kit is not factory installed, use the installation instructions supplied with the kit for field installation. Use the following procedure for reactive droop compensator adjustment.

⚠ WARNING

Hazardous voltage. Moving rotor. Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage**.** Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

7.12.2 Reactive Droop Compensator Adjustment Procedure

Parallel the two generator sets using the following procedure. Read and understand the entire procedure before beginning.

1. Remove any load connected to the generator set. Start each generator set by placing the generator set master switch in the RUN position.

2. Set the reactive droop compensator rheostat on generator set no. 1 to the minimum counterclockwise (CCW) setting. Record the RPM or frequency and voltage at 1/4 load steps to full load on unit no. 1

3. Repeat step 2 for generator set no. 2.

4. Compare the readings and make final adjustments so that the voltage is within 1 volt at each load step and the speed is within three RPM or the frequency is within 0.1 Hz for each unit. Adjust the voltage using the controller or remote voltage adjustment potentiometer. Adjust the speed at the electronic governor or at the remote adjusting potentiometer.

5. Check the droop compensation on each unit as follows:

   a. With unit no. 1 operating at the desired speed and voltage, apply an inductive load one half to full load. Do not use a resistive load for this test.

   b. Observe the voltmeter on unit no. 1 with the reactive droop compensator rheostat set at minimum. As the rheostat is turned clockwise (CW), the voltmeter should show a decrease in voltage. If observing a larger voltage, stop the

generator sets and reverse the direction of the generator load line through the current transformer or reverse the transformer leads on unit no. 1.

c. Restart the generator sets and recheck the droop on unit no. 1.

d. Set the reactive droop compensator rheostat to a value at approximately 4% below rated voltage at full load. As an example, the voltage droops (decreases) 19.2 volts on a 480-volt system at full load or 9.6 volts at one half load. Use the following formula for loads other than full load:

Rated Voltage x 0.04 x Actual Load (expressed as a % of full load) = Voltage Droop

Note: With full load 0.8 power factor, a droop of 3–5% should be adequate for paralleling.

6. Repeat step 5 for generator set no. 2. Adjust unit no. 2 where the voltage droop is equal and at the same point as on unit no. 1. The two units share reactive currents proportionately after correctly performing this procedure.

7. If reactive load is not available, go to Section 7.12.3, Reactive Droop Compensator Alternate Adjustment Procedure. If reactive load is available, go to Section 7.12.4, Testing.

7.12.3 Reactive Droop Compensator Alternate Adjustment Procedure

Initially calibrate each generator set using the following procedure.

1. Turn the reactive droop compensator rheostat on generator set no. 1 to the minimum setting.

2. Remove the controller cover. Move the voltage sensing lead from V7 to V9 at the AC fuse terminal block.

3. Remove any load connected to the generator set.

4. Start the generator set by placing the generator master switch in the RUN position.

5. Use the controller or remote voltage adjusting potentiometer on each generator set to fine adjust voltage as necessary.

6. Apply resistive load (1.0 power factor) until reaching rated current.

7. Adjust the reactive droop compensator rheostat to achieve a 4% droop (decrease) in voltage.

8. Remove the resistive load.

9. Stop the generator set by placing the generator master switch in the OFF position.

10. Return the voltage sensing lead from V9 to V7 at the AC fuse terminal block.

11. Replace the controller cover.

12. Repeat steps 1–11 for generator set no. 2.

7.12.4 Testing

Use the following procedure to check that the generator sets share the reactive load proportionately.

1. Parallel the units at one half to full load. Verify that each unit carries equal kW load or a load proportional to its capacity using the wattmeter readings. If load unbalance exists, adjust and recheck the electronic governor throttle control to correctly balance loading. Engine speed determines load sharing ability.

2. With the load balanced, check the ammeters for equal current or proportional according to capacity. If the currents are incorrect, adjust the reactive droop compensator rheostat reducing the current of the unit with the highest reading. Reduce the current to an equal division or proportionately.

3. Stop each generator set by placing the generator master switch in the OFF position.

Note: Step 1 balances the load using the electronic governor and step 2 balances the current using the reactive droop compensator. Consider these settings optimum for parallel operation.

Note: Voltage must droop (decrease) on lagging power factor loads (inductive loads). A small change in voltage is acceptable on unity power factor loads (resistive loads).

7.13 Gauge Senders

The resistance of the oil pressure and water temperature sender output signals varies as the respective pressure and temperature change. Use the resistance change for verification of sender function. Disconnect all leads from the sender before checking resistance. If the sender functions and the gauge does not function, check the engine wiring harness, leads, and connectors before replacing the gauge.

Note: Some generator sets may have senders/switches incorporated with the engine ECM (electronic control module). Identify engine ECM senders/switches by lead designations listed in the following testing information. Refer to Section 9, Wiring Diagrams for additional lead identification information. Use the engine service manual for troubleshooting ECM senders/switches.

7.13.1 Oil Pressure Sender Testing

Disconnect the oil pressure sender lead 7C. See Figure 7-21. Check the sender resistance with an ohmmeter. Compare the resistance values when the generator set is shut down and when it is running at operating temperature to the values shown in Section 1.2, Specifications.

Use a mechanical oil pressure gauge to further verify correct readings.

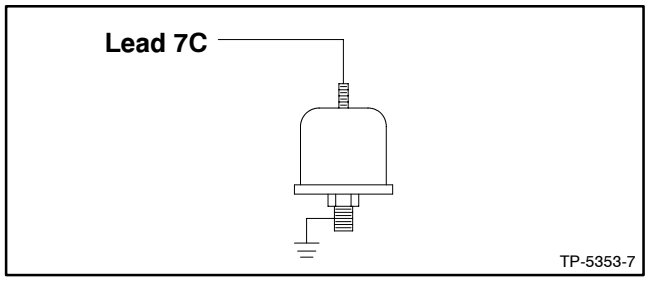


Figure 7-21 Oil Pressure Sender, Typical

7.13.2 Water Temperature Sender Testing

The water temperature sender is a single function, single-terminal type. See Figure 7-22.

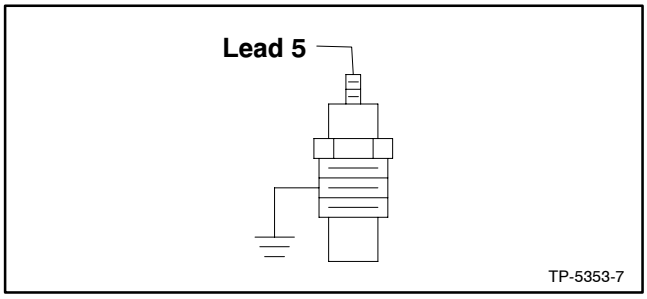


Figure 7-22 Water Temperature Sender, Typical

Disconnect the water temperature sender lead 5. Check the sender resistances with an ohmmeter. Compare the resistance values when the generator set is shut down and when it is running at operating temperature to the values in Section 1.2, Specifications.

7.14 Governor Adjustment

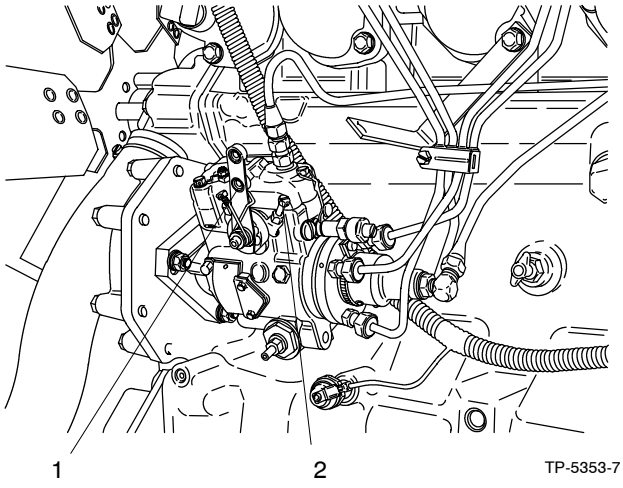
7.14.1 Mechanical Governor

Note: Before checking and adjusting engine speed, make sure the engine reaches its normal operating temperature.

Note: All speed specs apply to an engine at operating temperature under load conditions. The maximum permissible speed variation is 2–3 Hz or 50–90 rpm for fast idle speed.

Mechanical Governor Adjustment Procedure

1. Disconnect the speed control from the fuel injection pump lever and start the engine.
2. Verify that the injector pump lever holds in the fast idle position against the fast idle adjusting screw. See Figure 7-23.
3. Using a frequency meter, check the engine speed. Adjust the engine speed at full load to 1800 rpm (60 Hz) or 1500 rpm (50 Hz). To increase the engine speed, turn the fast idle adjusting screw counterclockwise; turn the fast idle adjusting screw clockwise to decrease engine speed.
4. Reconnect the speed control to the fuel injection pump lever.
5. Stop the generator set.

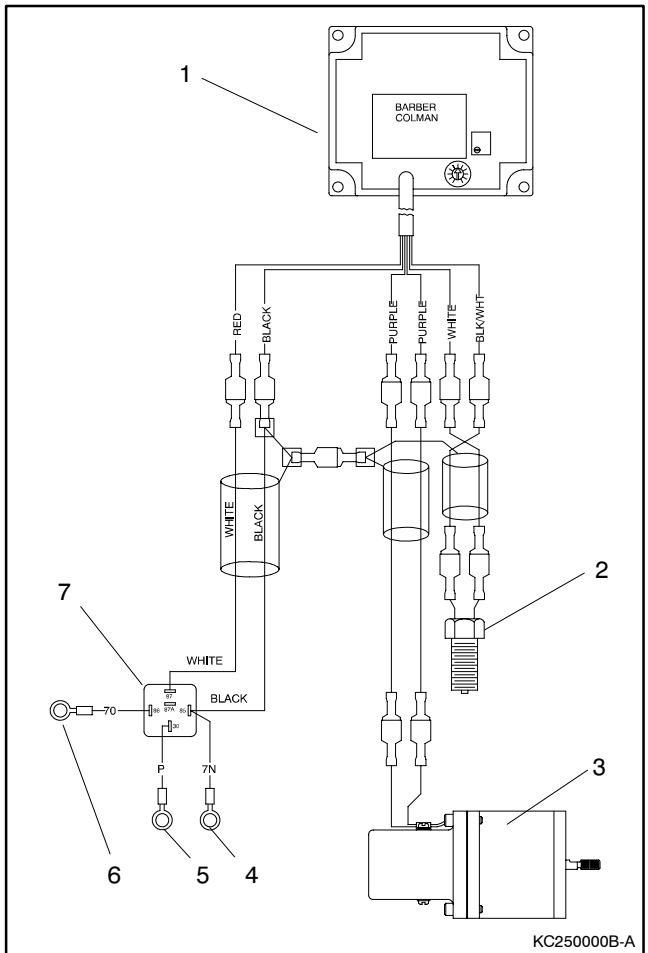


1. Injection pump lever
2. Fast idle adjusting screw

Figure 7-23 Governor Adjustments, Typical

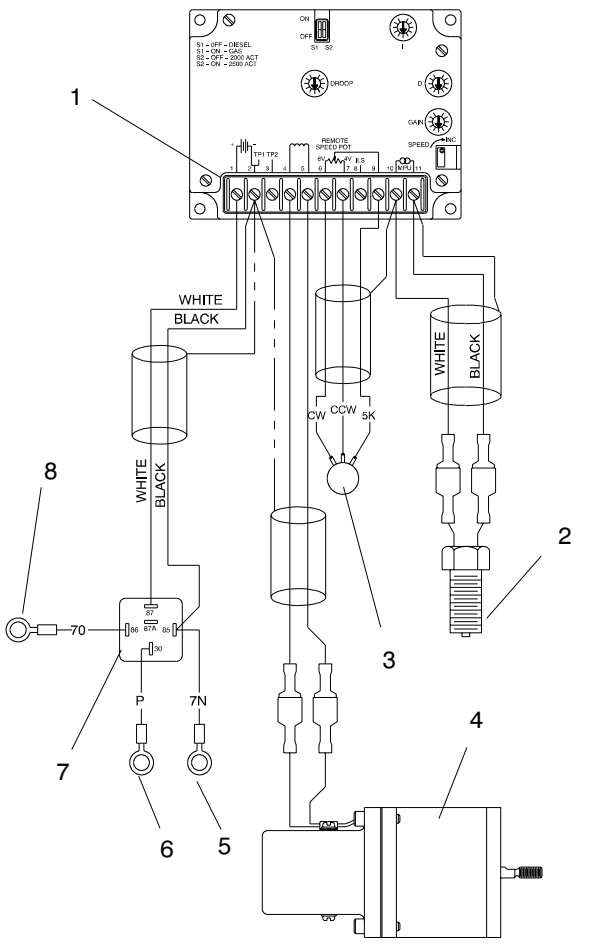
7.14.2 Electronic Governor—Barber-Colman Dyna 2500 125–150 kW John Deere Engine-Powered 6081

Some sets are equipped with Barber-Colman Dyna 2500 electronic governors. Because this is an electronic device, no mechanical drive or hydraulic connection is required. The system consists of a magnetic pickup, an electronic control unit, and an actuator. The magnetic pickup monitors engine speed and transmits this information to the electronic control unit (see Figure 7-24 or Figure 7-25). The electronic control unit interprets the signal from the magnetic pickup to control current input to the throttle actuator. The throttle actuator adjusts the throttle position on the engine. See Figure 7-26.



1. Control unit
2. Magnetic pickup
3. Actuator
4. Connect to safeguard breaker terminal strip
5. Connect to cranking solenoid, battery (+)
6. Connect to 70 on safeguard breaker terminal block
7. Relay

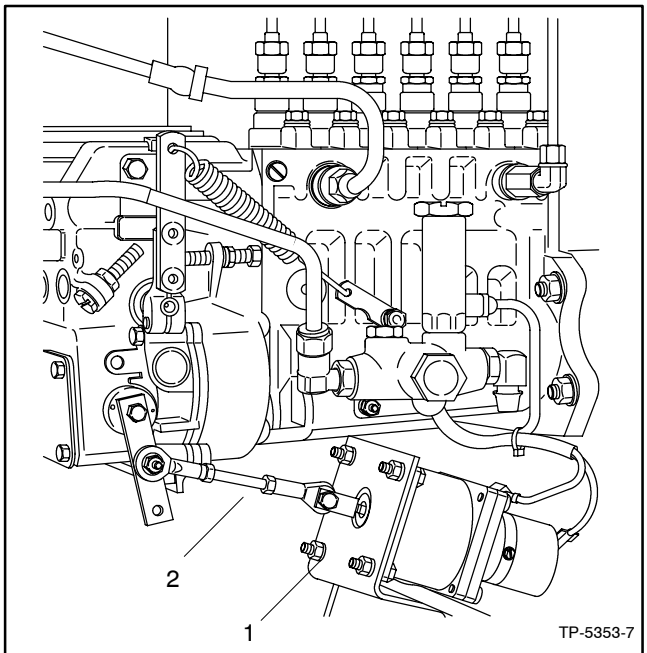
Figure 7-24 Governor Control Unit, Nonparalleling Generator Set



1. Control unit: terminal #1—positive, terminal #2—negative
2. Magnetic pickup
3. Optional remote speed potentiometer
4. Actuator
5. Connect to safeguard breaker terminal strip
6. Connect to cranking solenoid, battery (+)
7. Relay
8. Connect to 70 on safeguard breaker terminal block

Figure 7-25 Governor Control Unit, Paralleling Generator Set

Adjust the actuator shaft linkage to hold the fuel injection pump lever in the stop position when the power is off. The magnetic pickup air gap is 0.36–0.71 mm (0.014–0.028 in.).



1. Actuator
2. Linkage

Figure 7-26 Throttle Actuator (Barber-Colman Dyna 2500, John Deere 6076 Shown)

The Barber-Colman control unit is equipped with switches S1 and S2. Before making governor adjustments, verify that S1 and S2 are in the correct positions for your application. See Figure 7-27. Switch S1 selects the controller response range based upon engine type. Place switch S2 to match the control unit of the governor actuator. These generator sets use the Dyna 2500 actuator.

Fuel Type	**S1 Switch Position**
Diesel	Off
Control Unit Type	**S2 Switch Position**
Dyna 2500	On (in all cases)

Figure 7-27 Electronic Governor Switch Settings

Preliminary Adjustment Procedure

1. Place the generator set master switch in the OFF position. Do not run the generator set.

2. Set the control unit "I" adjustment one division from zero, the "D" adjustment four divisions from zero, and the gain adjustment at the third division from zero.

3. For isochronous operation, turn the droop adjustment potentiometer counterclockwise (CCW) to the minimum position. For droop operation, turn the droop potentiometer to the desired droop. Droop adjustment may be necessary with parallel generator operation.

   Note: If the governor uses the full stroke of the actuator shaft and the linkage adjustment uses only the active fuel range, the maximum obtainable droop would be approximately 12% at full load.

4. Position the actuator lever to hold the fuel pump lever in the STOP position when the power is off. Adjust the actuator linkage for smooth, non-binding operation.

Final Adjustment Procedure

1. Place the generator set master switch in the RUN or TEST position to start the generator set.

2. Adjust the control unit speed potentiometer until the engine operates at the desired rpm (50 or 60 Hz on the frequency meter).

3. If governing is unstable, turn the "I" and gain potentiometers slightly CCW.

   Note: Except for the speed potentiometer, control unit potentiometers have internal stops at 0 and 100%.

4. With the engine running at no load, finalize the "I", "D", and gain adjustments.

5. Slowly turn the gain adjustment potentiometer clockwise (CW) until the output shaft and linkage oscillates. Slowly turn the gain adjustment potentiometer CCW until the actuator lever stabilizes.

6. Jog the actuator lever by hand. If the actuator lever oscillates three to five times and then stabilizes, the gain setting is correct.

7. Turn the gain potentiometer one division CCW.

8. Turn the "D" adjustment fully CW while observing the actuator shaft. If the lever does not become unstable, jog it by hand. When the lever oscillates, turn the "D" adjustment CCW slowly until the actuator shaft stabilizes. Jog the lever again, it should oscillate 3–5 times and then become stable. If the system response to load changes is satisfactory at this point, omit step 9 and proceed to step 10.

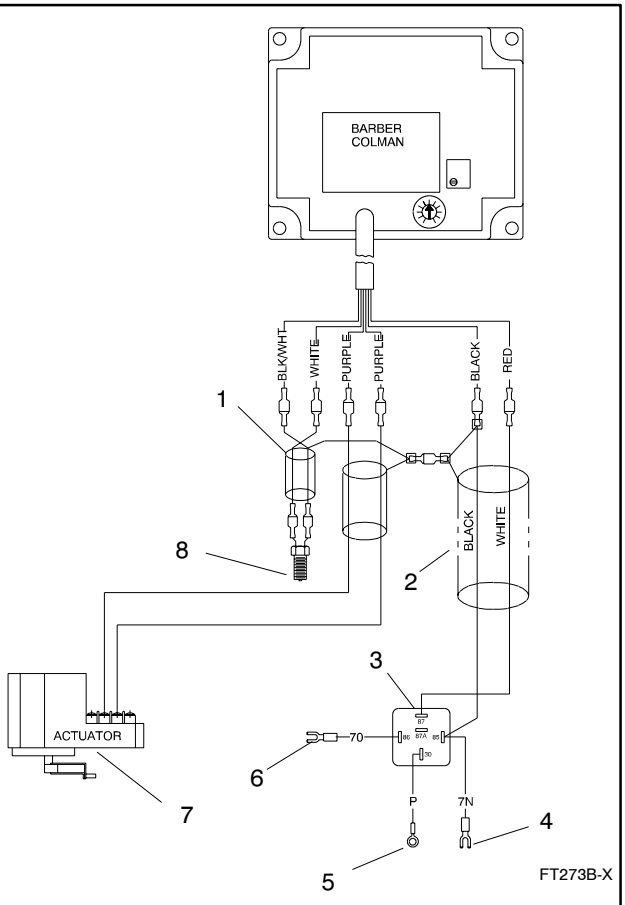
9. Turn the "I" potentiometer fully CW and watch the actuator shaft. If the actuator lever does not become unstable, jog it by hand. When the actuator lever slowly oscillates, slowly turn the "I" potentiometer CCW until the lever stabilizes.

10. Jog the actuator lever by hand. It should oscillate 3–5 times before stabilizing. The governor is now calibrated.

11. Stop the generator set.

7.14.3 Electronic Governor, Barber-Colman Dyna 70025 using Stanadyne D Series Injection Pump 35–99 kW John Deere Engine-Powered 4045 and 6068

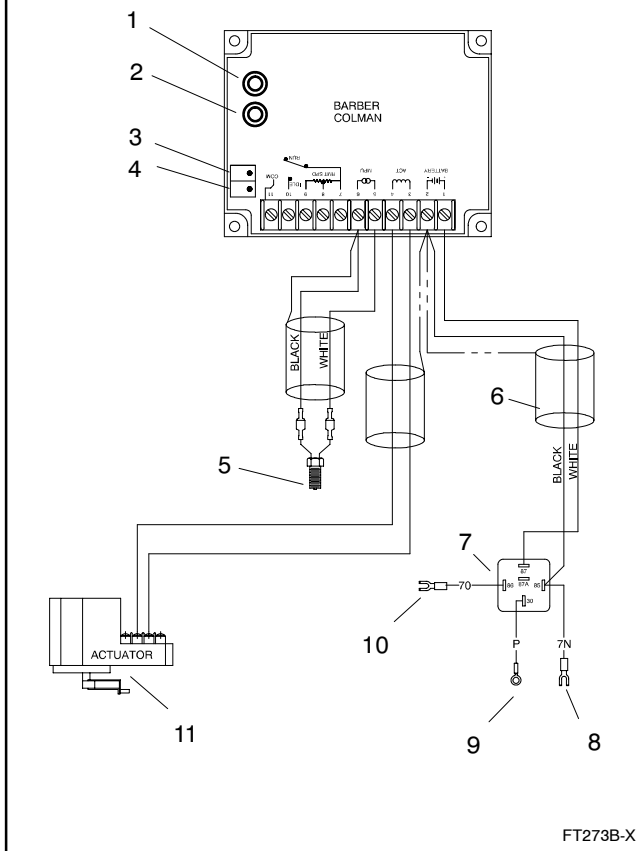
Some sets are equipped with Barber-Colman Dyna 70025 electronic governor used in conjunction with a Stanadyne D Series injection pump. This particular setup uses different governor controllers for a nonparalleling generator set or a paralleling generator set. The system consists of a magnetic pickup, an electronic control unit, and an actuator. The magnetic pickup monitors engine speed and transmits this information to the electronic control unit.



1. Twist magnetic pickup leads before connecting to control. 1 turn per 25 mm (1inch)
2. Power cable
3. Relay
4. Connect to safeguard breaker terminal strip
5. Connect to cranking solenoid, battery (+)
6. Connect to 70 on safeguard breaker terminal strip
7. Actuator
8. Magnetic pickup

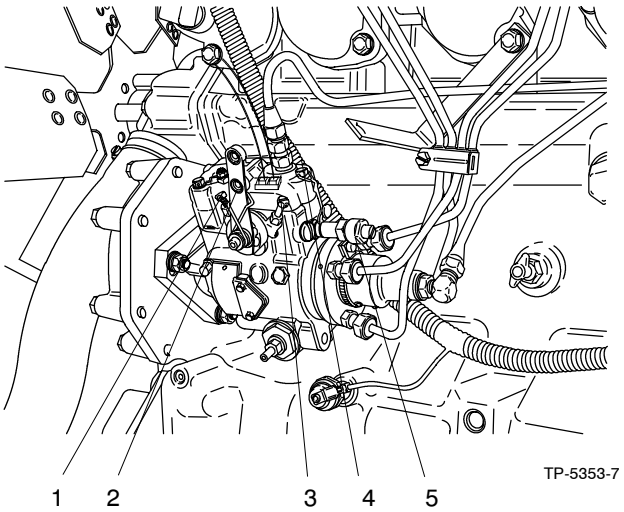
Figure 7-28 Governor Control Unit, Nonparalleling Generator Set

See Figure 7-28 for nonparalleling generator sets or Figure 7-29 for paralleling generator sets. The electronic control unit interprets the signal from the magnetic pickup to control the current input to the throttle actuator. The integrated throttle actuator adjusts the throttle position internally in the fuel injection pump. See Figure 7-30. The magnetic pickup air gap is 0.36–0.71 mm (0.014–0.028 in.).



1. Droop potentiometer
2. Gain potentiometer
3. Idle speed potentiometer
4. Run speed potentiometer
5. Magnetic pickup
6. Power cable
7. Relay
8. Connect to safeguard breaker terminal strip
9. Connect to cranking solenoid, battery (+)
10. Connect to 70 on safeguard breaker terminal strip
11. Actuator

Figure 7-29 Governor Control Unit, Paralleling Generator Set



1. Low idle adjustment screw
2. High idle adjustment screw
3. Injector pump/actuator
4. Shutoff shaft assembly
5. Droop adjusting screw

Figure 7-30 Governor Adjustments, Typical

Actuator Calibration Procedure

Use the following procedure to set up the mechanical governor for operation with the electronic integrated actuator. Perform calibration of both the mechanical and electronic governor in order for the system to operate correctly. Lack of maximum power or poor steady state speed control results from incorrect calibration. See Figure 7-30.

Note: The factory actuator calibration procedure requires no additional adjustment. Perform the actuator calibration procedure only if removal of the fuel injection pump occurs or the adjustment is questionable. Do not perform this procedure unless it is deemed necessary.

1. Turn the shutoff shaft assembly in the fuel injection pump clockwise to the on position. The shutoff shaft assembly is the lever located on the backside of the fuel injection pump. Secure using existing mechanical linkage.

2. Place the throttle shaft assembly in the high idle position. Back out the low idle adjustment screw a maximum of three turns. Excessive backing out of the low idle screw results in the disengagement of the pump's internal components.

   Note: Follow this procedure carefully to prevent engine overspeed and damage to the generator or other load.

3. Turn the droop adjusting screw counterclockwise until it stops. Only paralleling generator sets use the droop adjustment.

   Note: Turn the droop adjusting screw clockwise (CW) two full turns. The mechanical governor is now set in a position that permits starting the engine to calibrate the electronic integrated actuator governor. Do not operate the engine without the electronic governor connected and the system calibrated correctly as described in the following procedure. After making this droop adjustment, do not readjust.

Governor Calibration for Nonparalleling Generator Sets

Preliminary Adjustments

1. Place the generator set master switch in the OFF position. Do not run the generator set.

2. Set the gain adjustment three divisions from zero.

Final Adjustments

1. Place the generator set master switch in the RUN position to start the generator set.

2. Adjust the control unit speed potentiometer until the engine operates at the desired rpm (50 or 60 Hz on the frequency meter).

3. If governing is unstable, turn the gain potentiometer slightly counterclockwise.

   Note: Gain potentiometer has internal stops at 0 and 100%.

4. With the engine running at no load, finalize the gain adjustment. Turn the gain adjustment clockwise until the output shaft and linkage stabilizes. Upset the linkage by hand. If the linkage oscillates 3–5 times and then stops, the setting is correct.

5. Stop the generator set.

Governor Calibration for Paralleling Generator Sets

Calibration Procedure

1. Place the generator set master switch in the OFF position. Do not run the generator set.
2. Set the gain potentiometer at 30% and turn the droop potentiometer completely counterclockwise.
3. Turning the 20-turn potentiometer clockwise increases idle speed and turning it counterclockwise decreases idle speed.
4. Turning the 20-turn potentiometer clockwise increases run speed and turning it counterclockwise decreases run speed.
5. Place the generator set master switch in the RUN or TEST position to start the generator set.
6. Slowly turn the gain potentiometer clockwise until the engine becomes unstable. After the engine becomes unstable, slowly turn the gain potentiometer counterclockwise until stable. Interrupt the governor by momentarily removing power from the governor. The engine should recover in 3–5 seconds with diminishing oscillation.
7. Stop the generator set.

Droop Adjustment Procedure

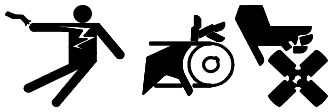
1. Place the generator set master switch in the RUN or TEST position to start the generator set.
2. Use the run speed potentiometer to set the engine rpm to the desired no load speed (frequency) on the frequency meter.
3. Apply full load to the generator set.
4. While observing the frequency meter, slowly turn the droop potentiometer clockwise to the desired droop percentage.
5. Remove full load from the generator set.
6. Using the run speed potentiometer, readjust the engine rpm to the desired no load speed (frequency) on the frequency meter.
7. Stop the generator set.

Before beginning the generator set disassembly procedure, carefully read all safety precautions at the beginning of this manual. Please observe these precautions and those included in the text during the disassembly/ reassembly procedure.

The following procedures cover many models and some steps may not apply to a particular engine. Use Figure 8-1 and Figure 8-2 to help understand component descriptions and general configuration of the generator set.

Use the disassembly procedure as a step-by-step means to help take apart the generator set. The disassembly procedure provides important information to minimize disassembly time and indicates where special configurations exist which may require taking notes. The reassembly procedure includes important alignment steps and provides critical torque specs.

⚠ WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

⚠ WARNING

Hot engine and exhaust system.
Can cause severe injury or death.

Do not work on the generator set until it cools.

Servicing the exhaust system. Hot parts can cause severe injury or death. Do not touch hot engine parts. The engine and exhaust system components become extremely hot during operation.

⚠ WARNING

Explosive fuel vapors.
Can cause severe injury or death.

Use extreme care when handling, storing, and using fuels.

The fuel system. Explosive fuel vapors can cause severe injury or death. Vaporized fuels are highly explosive. Use extreme care when handling and storing fuels. Store fuels in a well-ventilated area away from spark-producing equipment and out of the reach of children. Never add fuel to the tank while the engine is running because spilled fuel may ignite on contact with hot parts or from sparks. Do not smoke or permit flames or sparks to occur near sources of spilled fuel or fuel vapors. Keep the fuel lines and connections tight and in good condition. Do not replace flexible fuel lines with rigid lines. Use flexible sections to avoid fuel line breakage caused by vibration. Do not operate the generator set in the presence of fuel leaks, fuel accumulation, or sparks. Repair fuel systems before resuming generator set operation.

Perform the following steps before disassembling the generator set.

Remove the Generator Set from Service

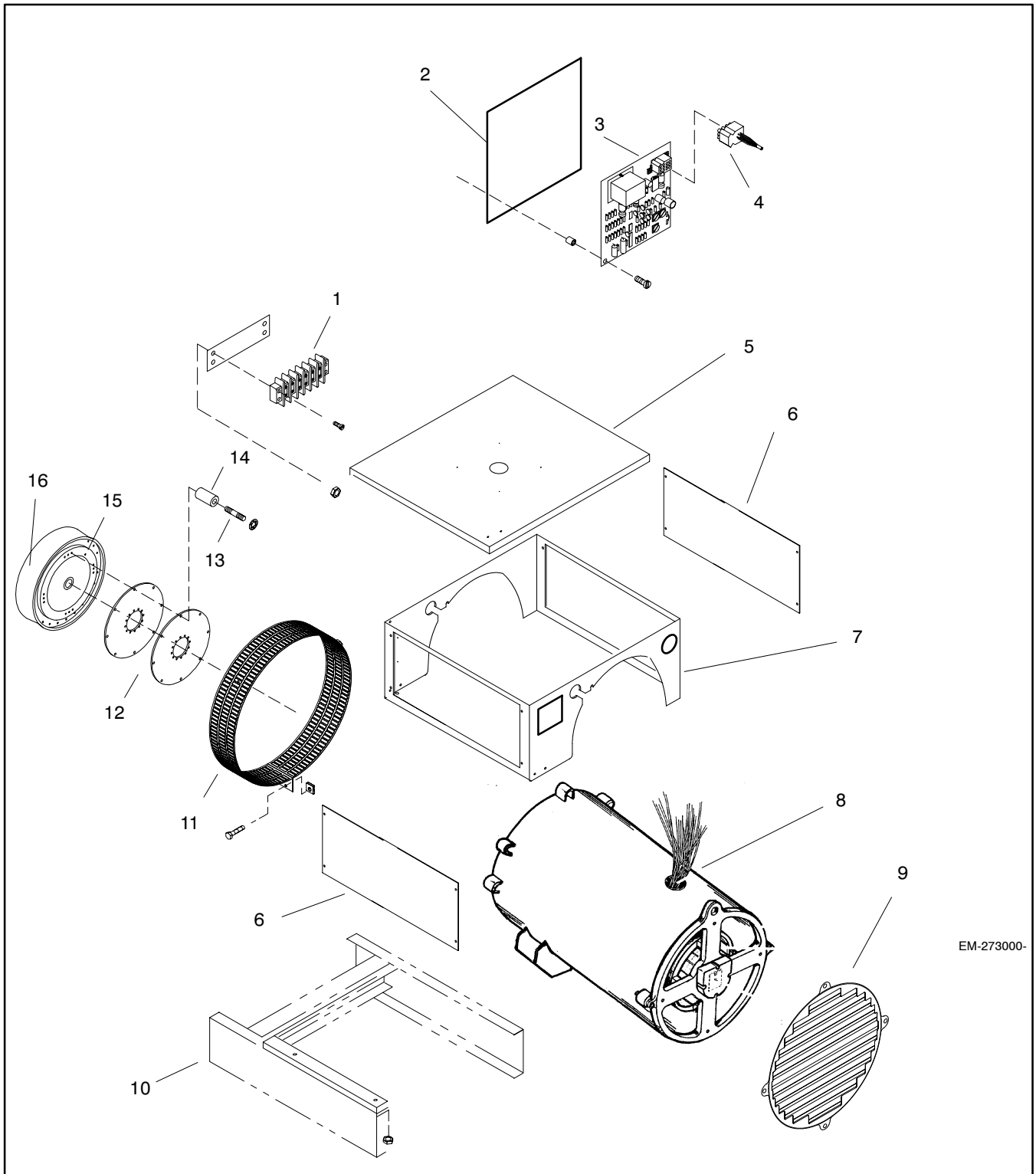
1. Disconnect the generator set engine starting battery, negative (–) lead first and remove the starting batteries from the work area to prevent fire hazard.

2. Disconnect the AC-powered accessories, such as the battery charger, block heater, and fuel transfer pump.

3. Shut off the fuel supply. Drain the fuel system as necessary by emptying fuel into proper containers. Remove any fuel containers from the work area to prevent fire hazard. Ventilate the work area to clear fumes.

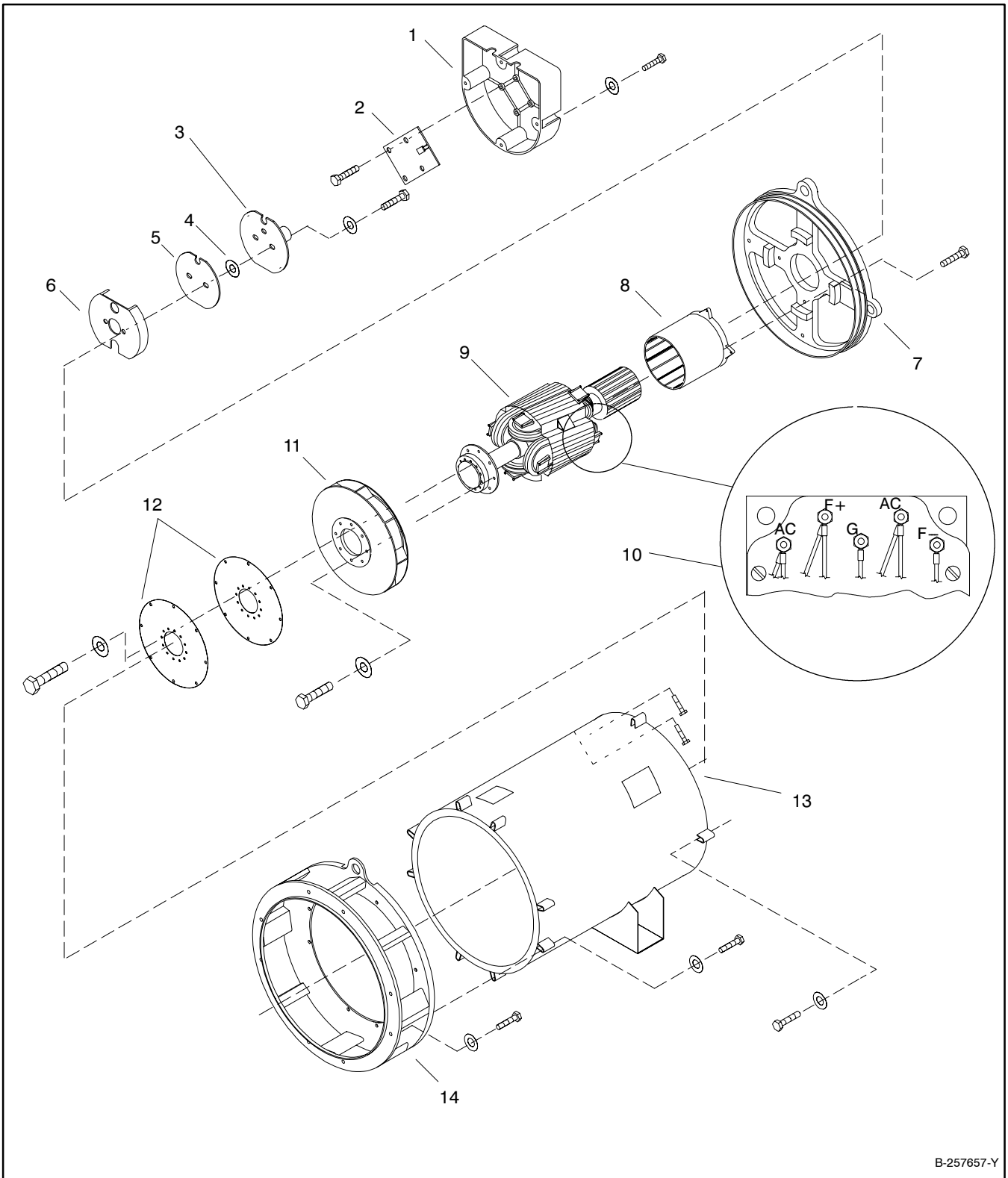
4. Disconnect the fuel, cooling, and exhaust systems as necessary to tilt the generator set. Disconnect the output leads or load circuit cables at the generator set.

5. Any cranes, hoists, or other lifting devices used in the disassembly or reassembly procedure must be rated for the weight of the generator set. Check the generator set nameplate or spec sheet for weight.



1. Voltage regulator terminal strip
2. Voltage regulator panel
3. Voltage regulator
4. Voltage regulator wiring harness
5. Junction box cover
6. Junction box panel
7. Junction box
8. Alternator assembly
9. End bracket cover
10. Skid
11. Generator fan guard
12. Drive discs
13. Stud
14. Spacer
15. Flywheel
16. Engine side of flywheel

Figure 8-1 Generator Set Components, Typical



1. LED circuit board cover
2. LED circuit board
3. Photo transistor board
4. Insulating washer
5. Insulator
6. Magnetic actuator
7. End bracket
8. Exciter field assembly
9. Rotor assembly
10. SCR assembly
11. Generator set fan
12. Drive discs
13. Stator assembly
14. Generator adapter

Figure 8-2 Generator Set Components, Typical

8.1 Disassembly

1. Disconnect all controller-to-engine and engine-to-generator set harnesses and wiring. Disconnect the alarm horn circuit board connector, if equipped, the LED board and housing, and the speed sensor. Remove the junction box and controller as a unit.

2. Remove the bolts from the generator set vibromounts.

3. Suspend the generator set at both ends with hooks in the lifting eyes. Use a hoist to raise the generator set end off the vibromounts. See Figure 8-3.

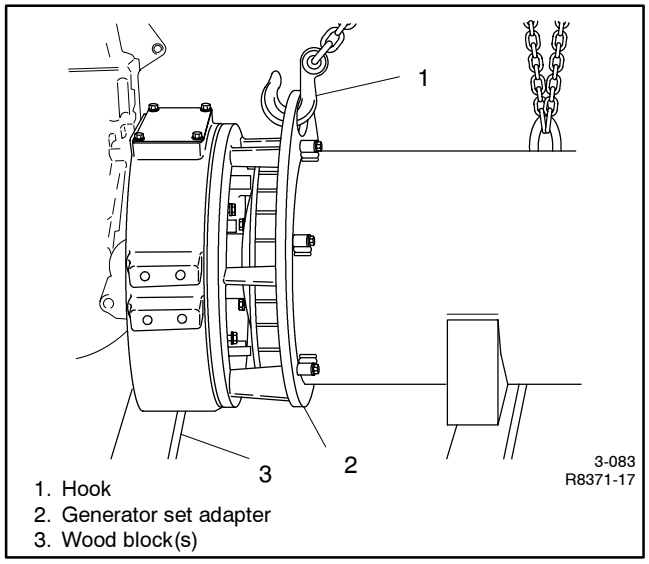
4. Support the engine by placing wood blocks under the flywheel housing. Lower the generator set end until the generator set flywheel housing rests on the blocks. See Figure 8-3.

5. Remove the fan guard. Remove the bolts holding the adapter to the flywheel housing.

6. Remove the nuts and spacers holding the drive discs to the flywheel.

7. Work the drive discs over the studs, if equipped, to separate the generator set from the engine. See Figure 8-4.

8. Set the generator set assembly on the floor in a horizontal position. Remove the support slings or chains.

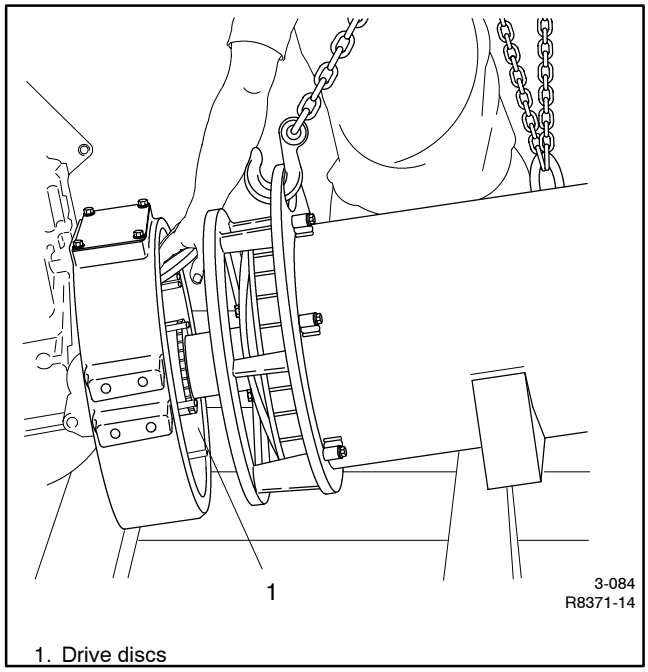


1. Hook
2. Generator set adapter
3. Wood block(s)

Figure 8-3 Hoisting Generator Set

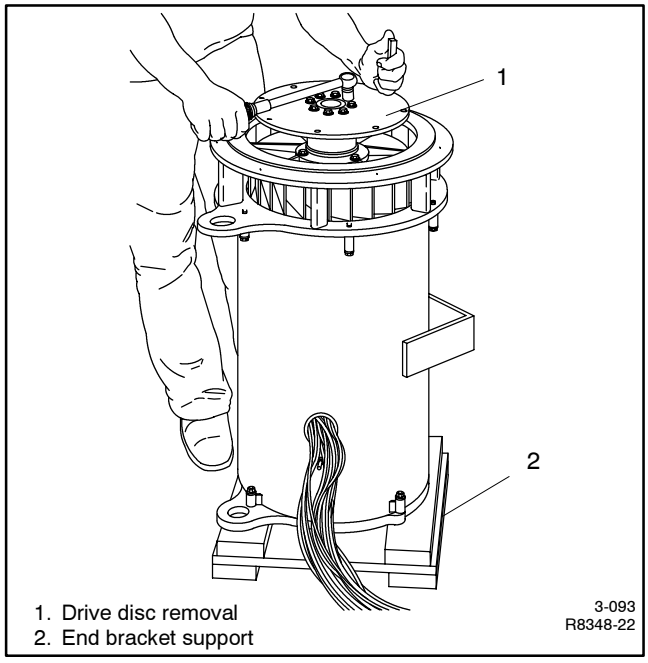
9. To remove the rotor assembly, hook the hoist to the adapter and place the generator set assembly on the floor in a vertical position. See Figure 8-5. Before lowering the assembly, place boards along the edge of the end bracket to prevent damage to the photo transistor board.

10. Remove the drive discs and fan from the generator set assembly. See Figure 8-5.



1. Drive discs

Figure 8-4 Separating Generator Set and Engine



1. Drive disc removal
2. End bracket support

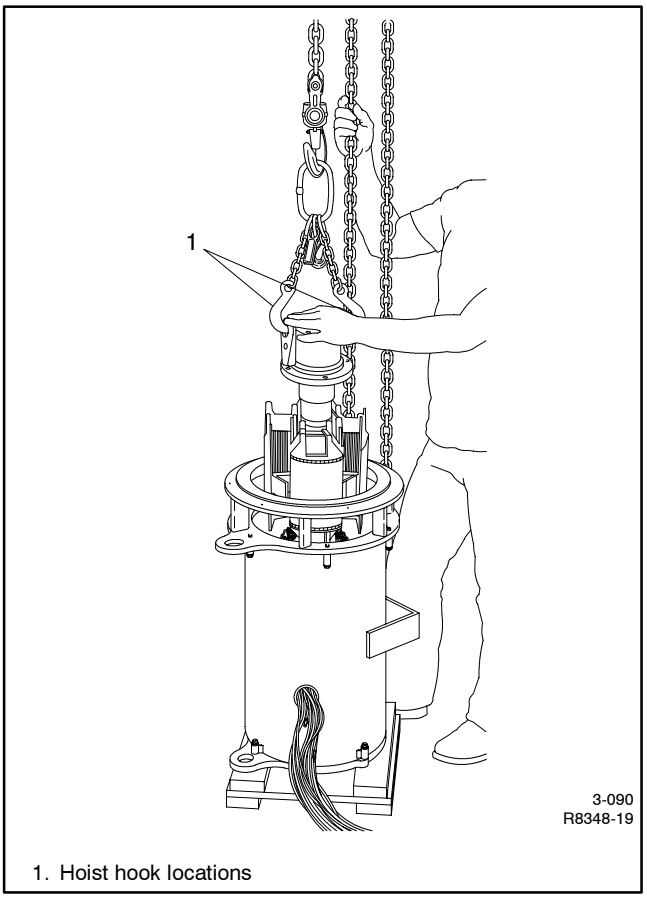
Figure 8-5 Generator Set Support, Drive Disc and Fan Removal

11. Fasten the lifting eye and hoist hook to the rotor flange. Carefully hoist the rotor to avoid damaging the exciter armature or exciter field magnets. See Figure 8-6.

12. While the rotor is suspended, remove the photo transistor board and actuator cup. Remove the F3, G, and AC leads from the SCR assembly. Cut off the photo transistor board terminals to remove the circuit board. If the photo transistor board is reused, leave the leads as long as possible.

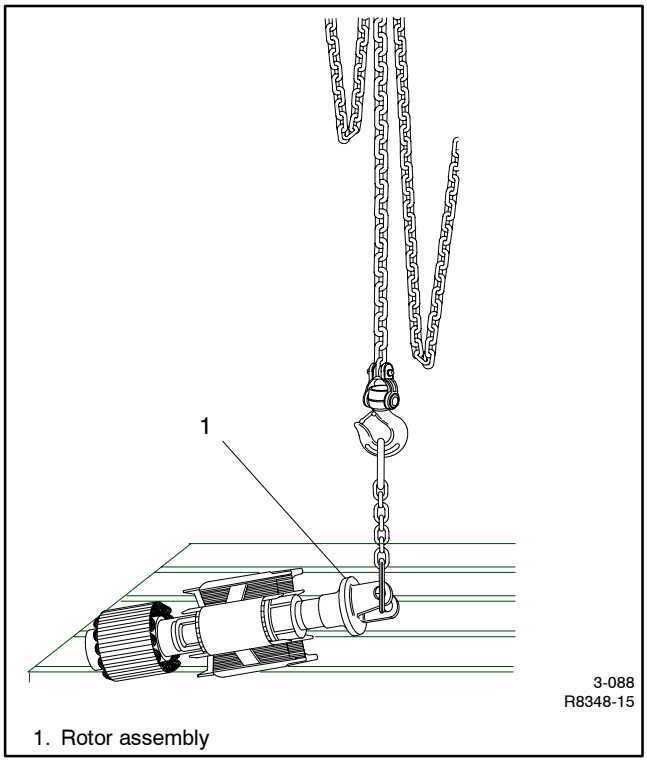
13. Slowly lower the rotor to a horizontal position. Set the rotor on a wooden surface. Take care not to damage the windings, laminations, or bearing. See Figure 8-7.

14. Place the generator set assembly on the generator set adapter end in order to remove the generator set adapter and end bracket from the stator. Fasten chains to the generator set adapter and lower to a horizontal position. Fasten the hook to the end bracket eye and hoist to a vertical position. See Figure 8-8.



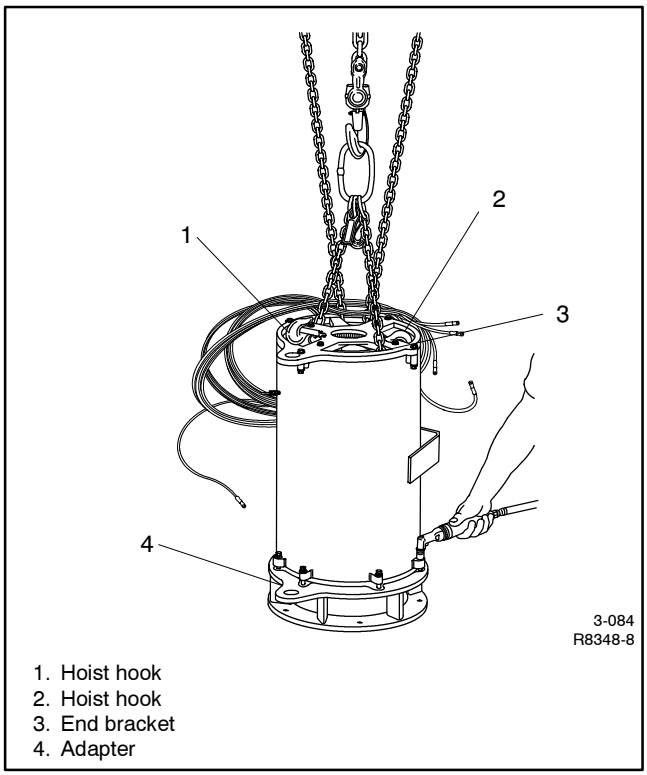
1. Hoist hook locations

Figure 8-6 Rotor Removal



1. Rotor assembly

Figure 8-7 Lowering Rotor



1. Hoist hook
2. Hoist hook
3. End bracket
4. Adapter

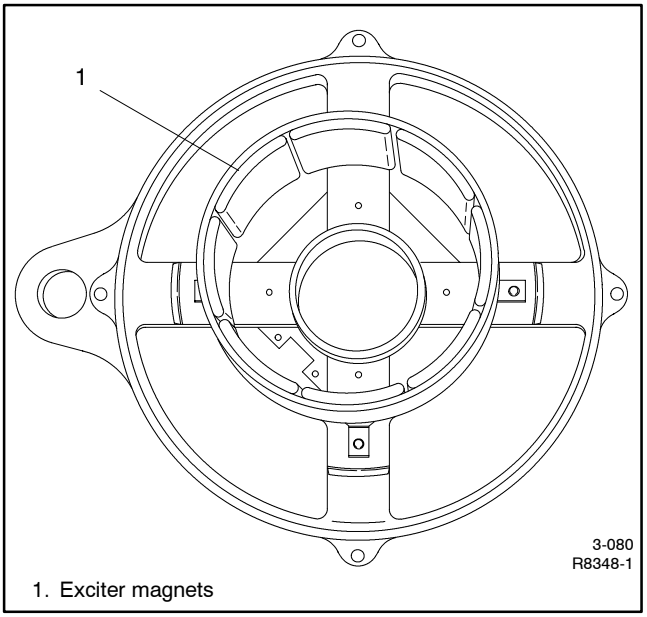
Figure 8-8 Removing Generator Set Adapter

15. Remove the generator set adapter mounting bolts. Fasten the hoist hooks to the end bracket and raise the assembly slightly. Bump the generator set adapter loose by using a rubber mallet.

16. Lower the stator assembly. Remove the end bracket mounting bolts. Separate the end bracket from the stator by bumping it loose with a rubber mallet.

17. Remove the exciter magnets from the end bracket. See Figure 8-9.

    Note: Some early models are equipped with a tolerance ring inside the end bracket bore.



1. Exciter magnets

Figure 8-9 End Bracket View

8.2 Reassembly

1. Attach the exciter field to the end bracket with four mounting screws. See Figure 8-9.

   Note: Some early models are equipped with a tolerance ring inside the end bracket bore. Install a new tolerance ring when reinstalling the end bracket.

2. Place the stator in a vertical position with the end bracket side up.

   Note: The end bracket side of the stator has four mounting bosses.

3. Place the end bracket on the stator and use bolts to align the holes. Use a rubber mallet to mount the end bracket flush with the stator. See Figure 8-10.

   Note: Position the end bracket housing eye opposite the stator mounting bracket during reassembly.

   Note: Early models use a skewed (slanted) stator with a straight rotor. When replacing either the rotor or stator, be sure replacement is the same as the original. Use dissimilar rotor and stator styles (skewed rotor with straight stator or straight rotor with skewed stator) when reassembling the generator set.

4. Install bolts and washers to attach the end bracket to the stator. Torque bolts to 47 Nm (35 ft. lbs.) maximum.

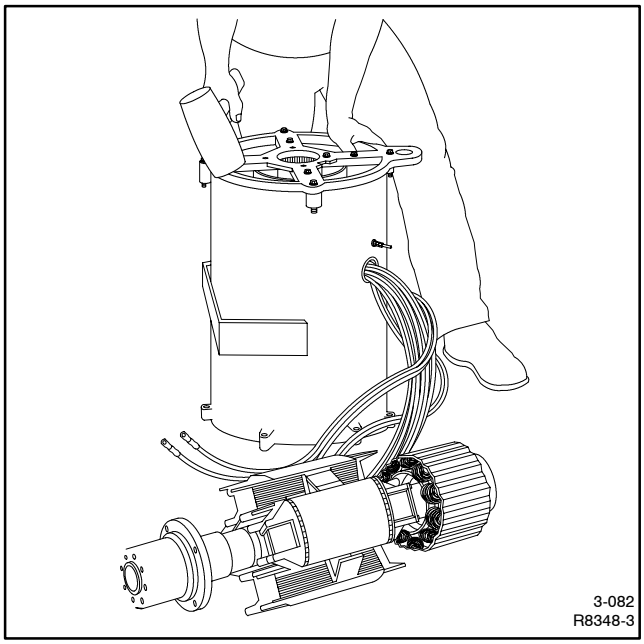


Figure 8-10 Mounting End Bracket on Stator

5. Attach the hoist hooks to the end bracket and suspend the stator. Place the generator set adapter on the floor and lower the stator to within 12.7–6.4 mm (0.05–0.25 in.) of the adapter lip. See Figure 8-11.

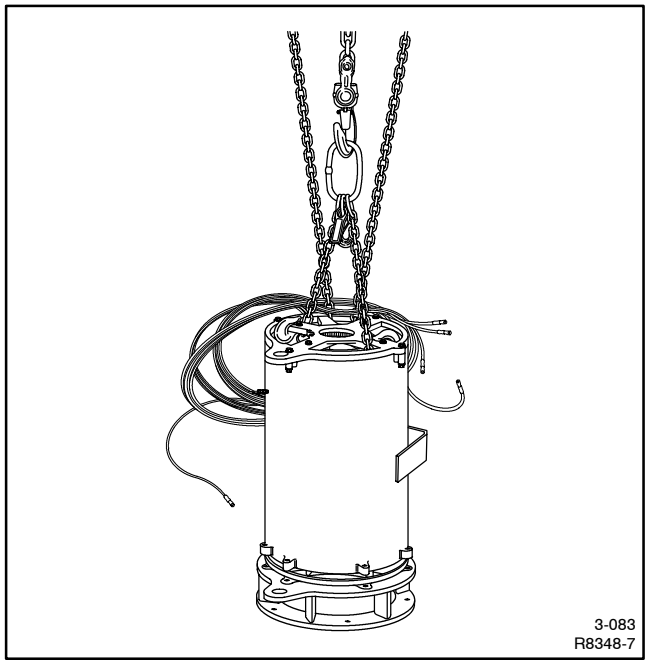


Figure 8-11 Aligning Adapter and Stator

6. Align the adapter with the stator and start the bolts with washers. Lower the stator onto the adapter and finish tightening the bolts.

   Note: Position the adapter hoisting eye so that it is opposite the stator mounting bracket and directly below the end bracket hoisting eye.

7. Place the generator set assembly on the end bracket end when installing the rotor. Fasten the hoisting hook to the end bracket eye and lower the generator set assembly to a horizontal position.

8. Attach the hoisting hooks to the adapter as shown in Figure 8-12. Suspend the generator set assembly. Before lowering the generator set, place boards along the edge of the end bracket. Maintain a 25 mm (1 in.) clearance underneath the center of the end bracket to prevent damage to the photo transistor board and actuator cup when installing the rotor.

9. Fasten the lifting eye and hoist hook to the rotor flange. See Figure 8-13. Hoist the rotor to a vertical position taking care not to damage the windings, laminations, or bearing.

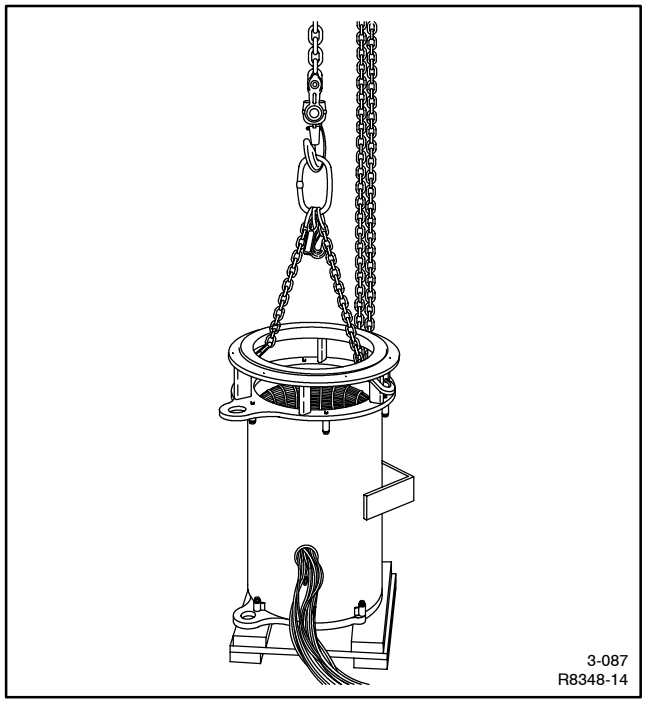


Figure 8-12 Supporting Generator Set Assembly

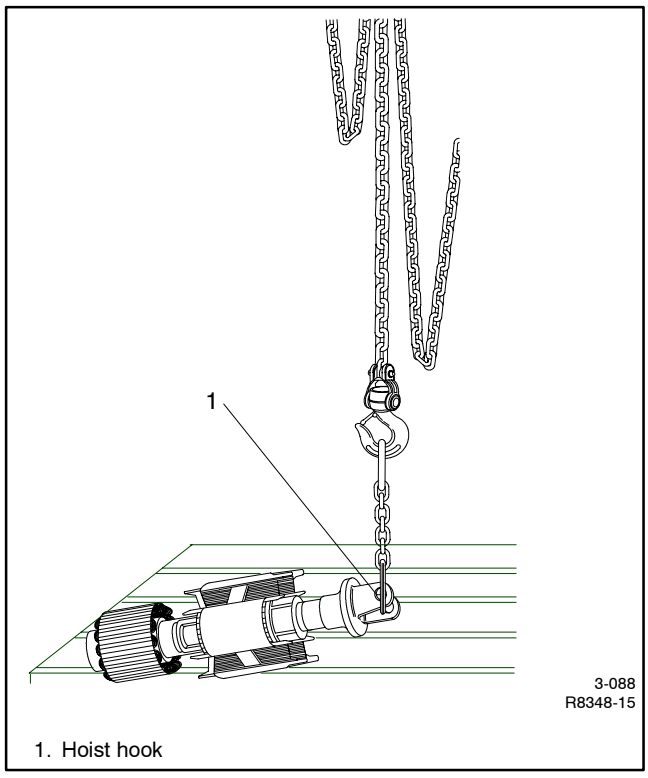


Figure 8-13 Hoisting Rotor

⚠ WARNING

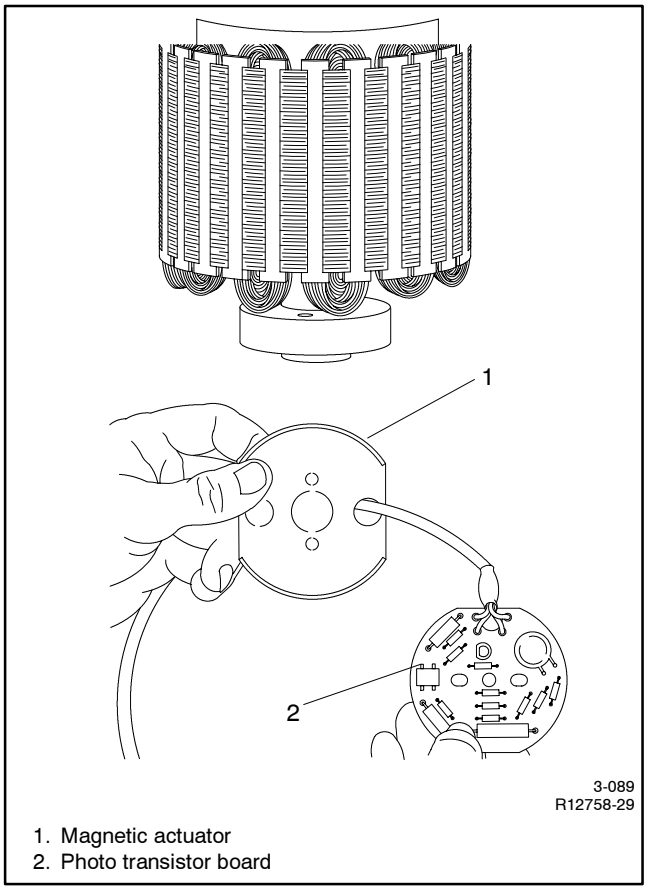
Hazardous voltage. Moving rotor. Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Installing the photo transistor circuit board. Hazardous voltage can cause severe injury or death. Ensure that the foil side of the photo transistor circuit board, the end of the shaft, and the threaded holes are clean and free of metal particles and chips. Metal debris may short-circuit the photo transistor circuit board and cause hazardous voltage in the generator set. Do not reconnect the generator set to the load until the AC voltmeter shows the correct output.

10. While the rotor is suspended, install the photo transistor board, insulator board, and actuator cup. Place the photo transistor board lead through the actuator cup as shown in Figure 8-14. Push the lead through the hole in the rotor shaft and then through the exciter laminations ending near the SCR assembly.

11. Attach the photo transistor board and magnetic actuator to the end of the rotor shaft with two mounting screws. See Figure 8-15. Cut off the excess lead wire, leaving enough wire to reach the SCR assembly. Strip 50–75 mm (2–3 in.) of the gray insulator jacket from the lead. Cut off all exposed uninsulated wire. Strip about 1/4 in. (0.6 mm) of insulation on the red and black leads and crimp on #8 electrical terminals (part no. X-283-7). Before connecting to the SCR studs, secure the leads with tie wraps. Reconnect the photo board white lead to the SCR AC stud, red lead to the F+ stud, green lead to the G stud, and black lead to the remaining AC stud. Secure the leads with stop nuts. Torque the connections to 0.9 Nm (8 in. lbs.) maximum.



1. Magnetic actuator
2. Photo transistor board

Figure 8-14 Installing Photo Transistor Board

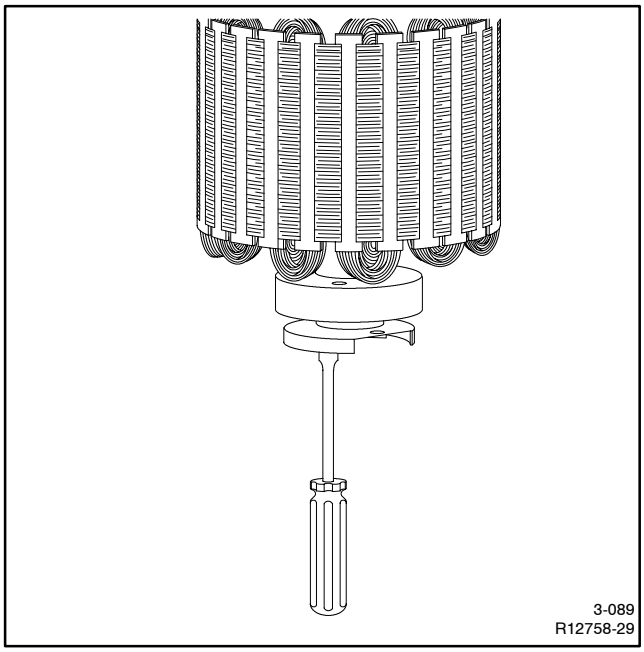


Figure 8-15 Mounting Photo Transistor Board and Magnetic Actuator

12. Suspend the rotor over the generator set assembly. Lower the rotor field into the stator. Be extremely careful while lowering the rotor to avoid damaging the exciter armature, field magnets, stator windings, or rotor laminations. See Figure 8-16. Carefully align the rotor bearing to the end bracket. Check for an outer race measurement of 0.6 mm (0.25 in.) from the bracket to the bearing. Make sure the photo transistor board and actuator cup have clearance below the end bracket.

13. Place the fan over the rotor flange and torque the bolts to 29 Nm (260 in. lbs.).

14. Attach the drive disc(s) to the end of the rotor shaft. Torque the drive disc mounting bolts to 68 Nm (50 ft. lbs.).

15. Attach the hoist to the adapter eye and place the generator set assembly in a horizontal position. Take care not to damage the rotor or stator. Position the generator set so that the hoisting eyes are to the top.

16. Apply Loctite® No. 271 red to the stud threads, if so equipped, and thread the studs completely into the flywheel as shown in Figure 8-17. Apply Loctite® No. 242 blue to the stud threads on the nut side.

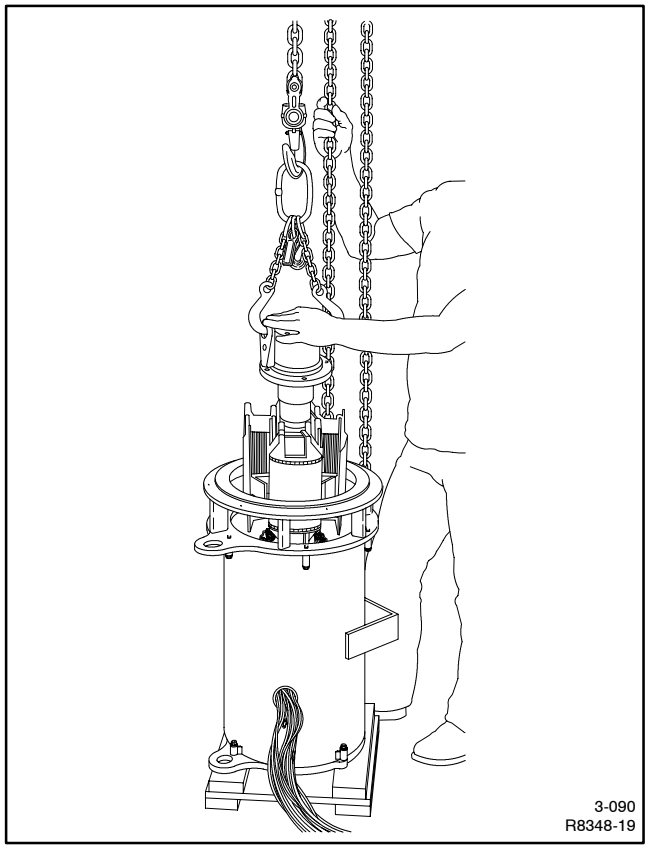
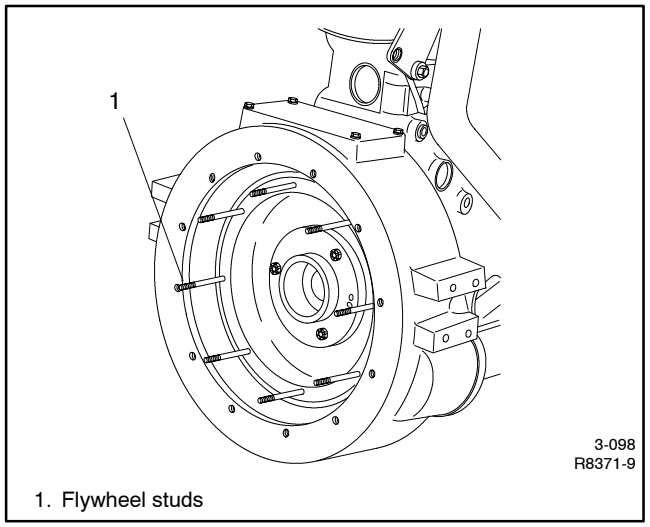


Figure 8-16 Installing Rotor

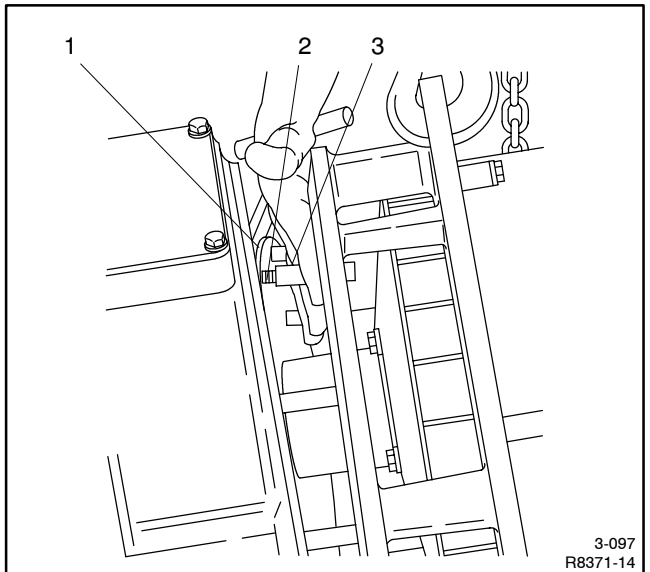


1. Flywheel studs

Figure 8-17 Flywheel Studs

17. Place the hoist hooks into the end bracket and the adapter eye. Raise the generator set assembly and align the studs with the drive discs by turning the flywheel. Move the generator set as necessary to work the drive discs over the studs. When the drive discs are about 25 mm (1 in.) over the studs, install the spacers, if equipped. See Figure 8-18.

    Note: Some models mount the drive discs to the flywheel using bolts. Some applications use hardened washers.



1. Drive discs
2. Studs
3. Spacers

Figure 8-18 Installing Spacers

18. Move the generator set as necessary to align the generator set adapter and flywheel housing. Fasten and final tighten the adapter to the flywheel housing using bolts and hardened lock washers. See Figure 8-19. Torque the bolts to the value given in Section 1, Specifications, Generator.

19. Install the nuts on the studs. Do not final tighten at this time.

    Note: Some models mount the drive discs to the flywheel using bolts. Some applications use hardened washers.

20. Hoist the generator set and engine slightly to remove the wood block(s) from under the flywheel housing. Align the generator set assembly and skid. Lower the generator set and tighten the vibromount mounting bolts.

21. Remove chains or slings used for suspending the generator set. Final tighten the drive discs to the flywheel. Torque the hardware to the values given in Section 1, Specifications, Generator.

22. Install the fan guard.

23. Install the speed sensor and set the speed sensor air gap at 0.36–0.71 mm (0.01–0.03 in.). See Figure 8-20. Replace the LED board/housing assembly on the end bracket.

24. Reinstall the junction box and controller. Reconnect all controller-to-engine and engine-to-generator set harnesses and wiring. Refer to the wiring diagrams as required.

25. Reconnect the fuel, cooling, and exhaust systems that were disconnected during disassembly. Reconnect the output leads or load circuit cables at the generator set. Open the fuel supply valve.

26. Reconnect the starting batteries, negative (–) lead last. Connect any AC-powered accessories such as a battery charger, block heater, fuel transfer pump, etc.

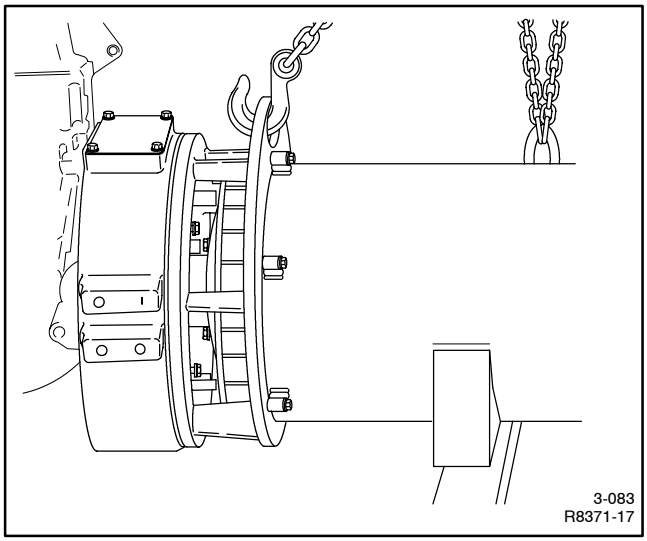
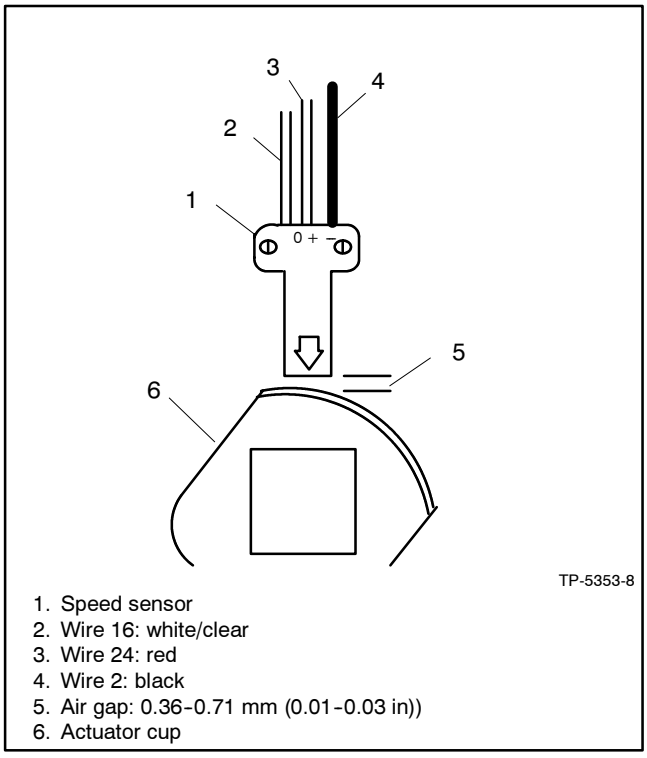


Figure 8-19 Aligning Adapter and Flywheel Housing

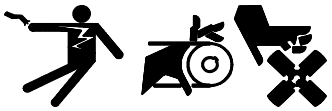


1. Speed sensor
2. Wire 16: white/clear
3. Wire 24: red
4. Wire 2: black
5. Air gap: 0.36–0.71 mm (0.01–0.03 in))
6. Actuator cup

Figure 8-20 Speed Sensor Air Gap

Notes

⚠ WARNING

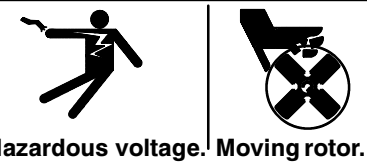


Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

⚠ WARNING



Hazardous voltage. Moving rotor.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocution is possible whenever electricity is present. Open the main circuit breakers of all power sources before servicing the equipment. Configure the installation to electrically ground the generator set, transfer switch, and related equipment and electrical circuits to comply with applicable codes and standards. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage. Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

Notes

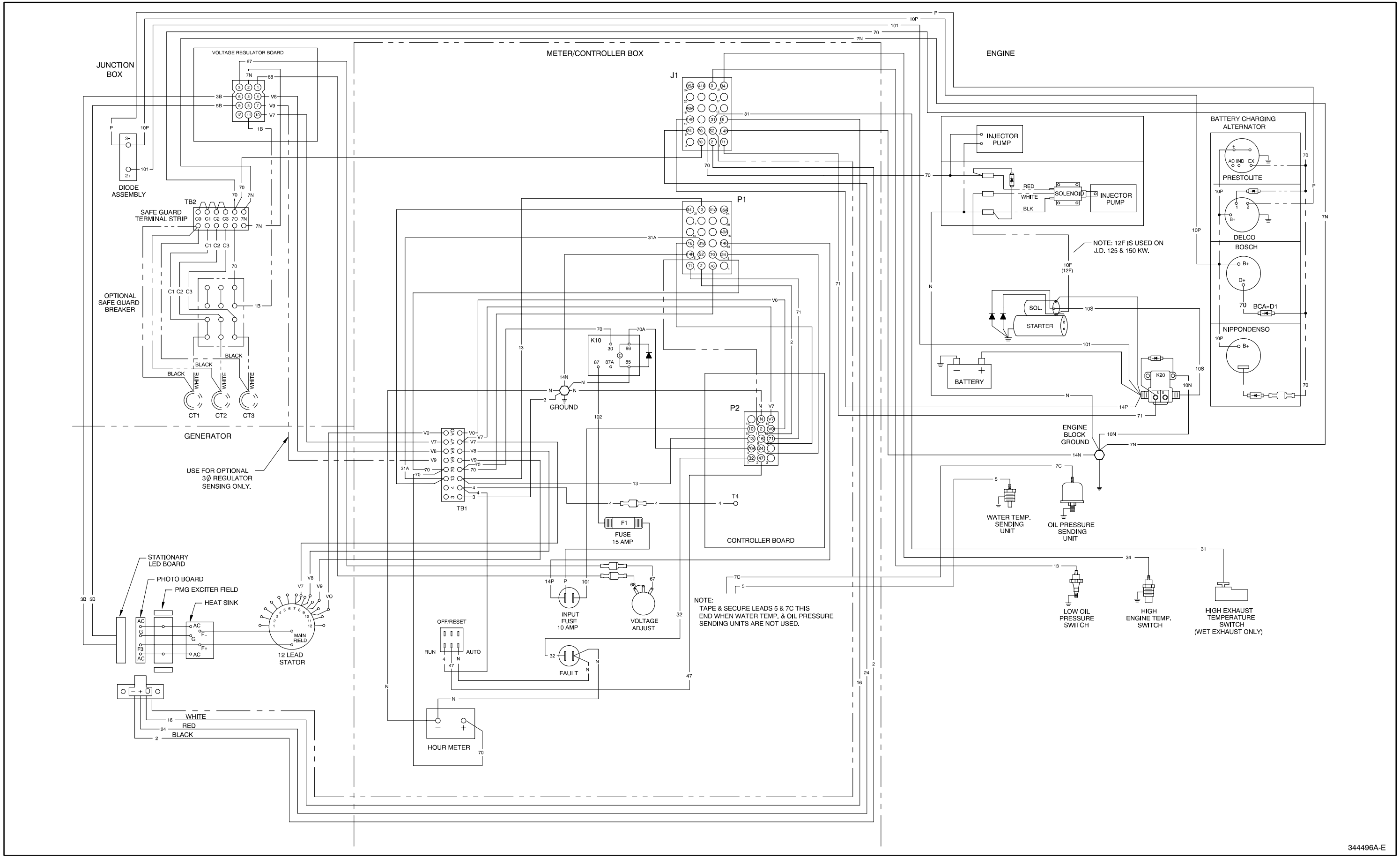


Figure 9-1 Wiring Diagram, Decision-Maker™ 1 Standard Controller (Sheet 1 of 3)

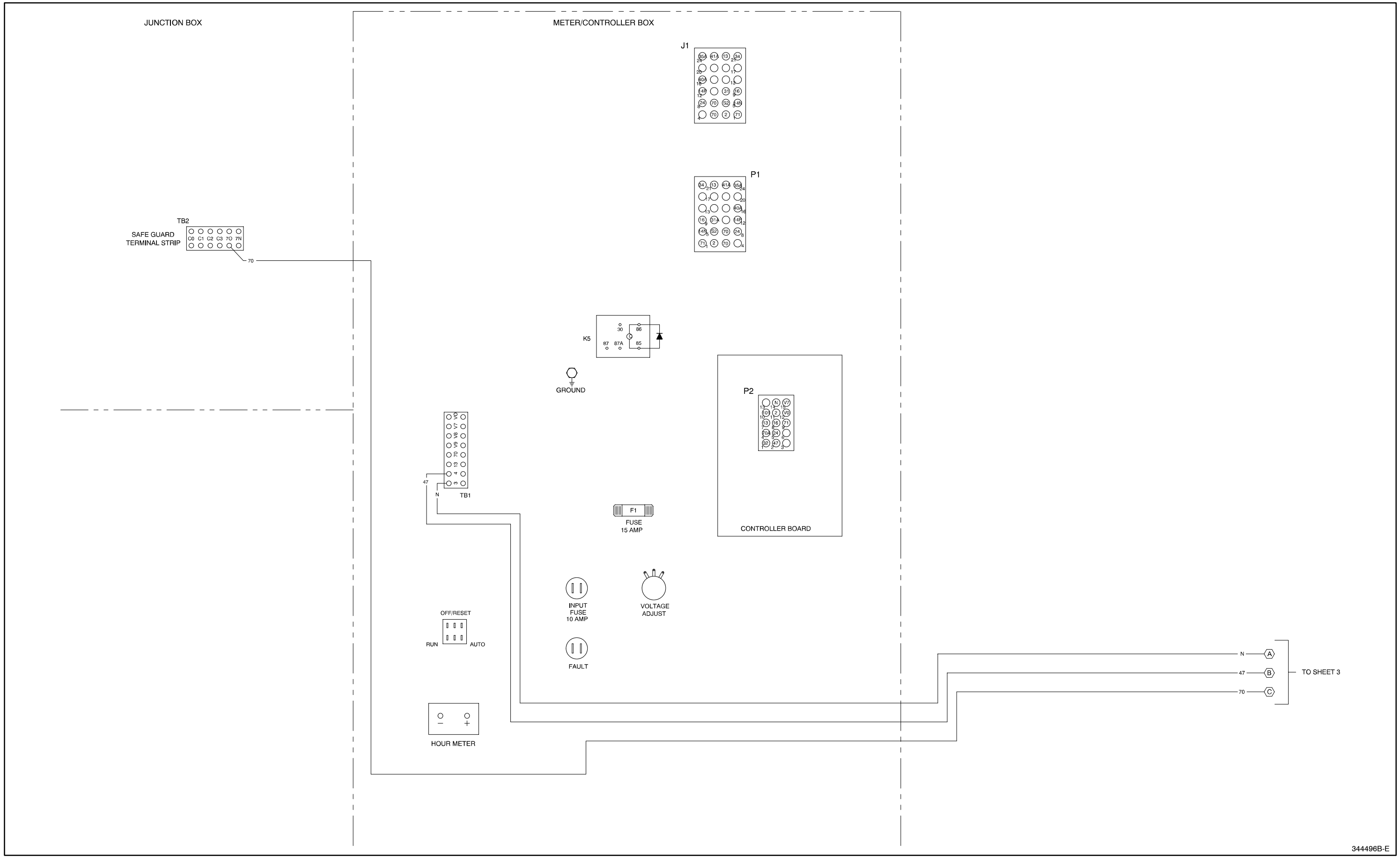
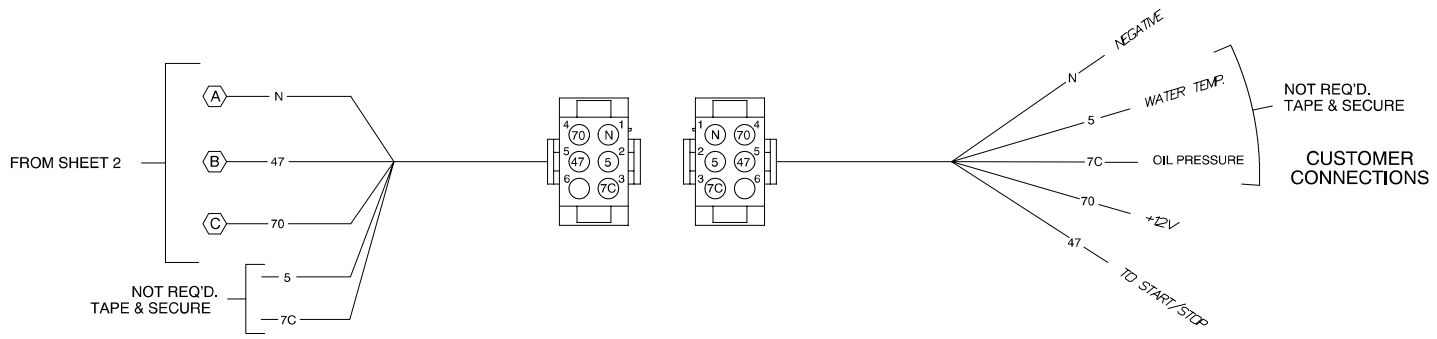
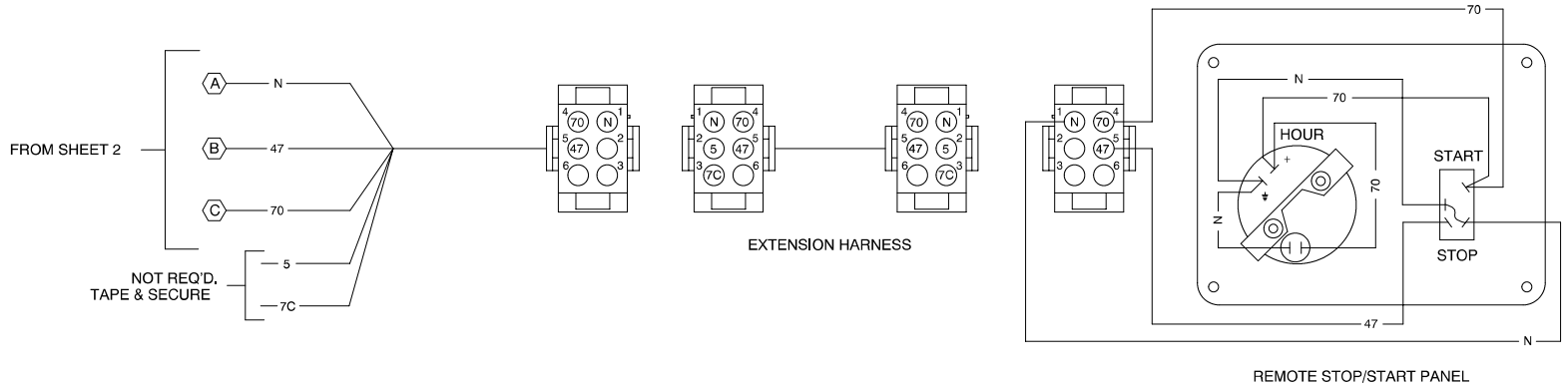


Figure 9-2 Wiring Diagram, Decision-Maker™ 1 Standard Controller, Remote Panel Options (Sheet 2 of 3)



CUSTOMER SUPPLIED REMOTE PANEL (START/STOP ONLY)



REMOTE STOP/START PANEL

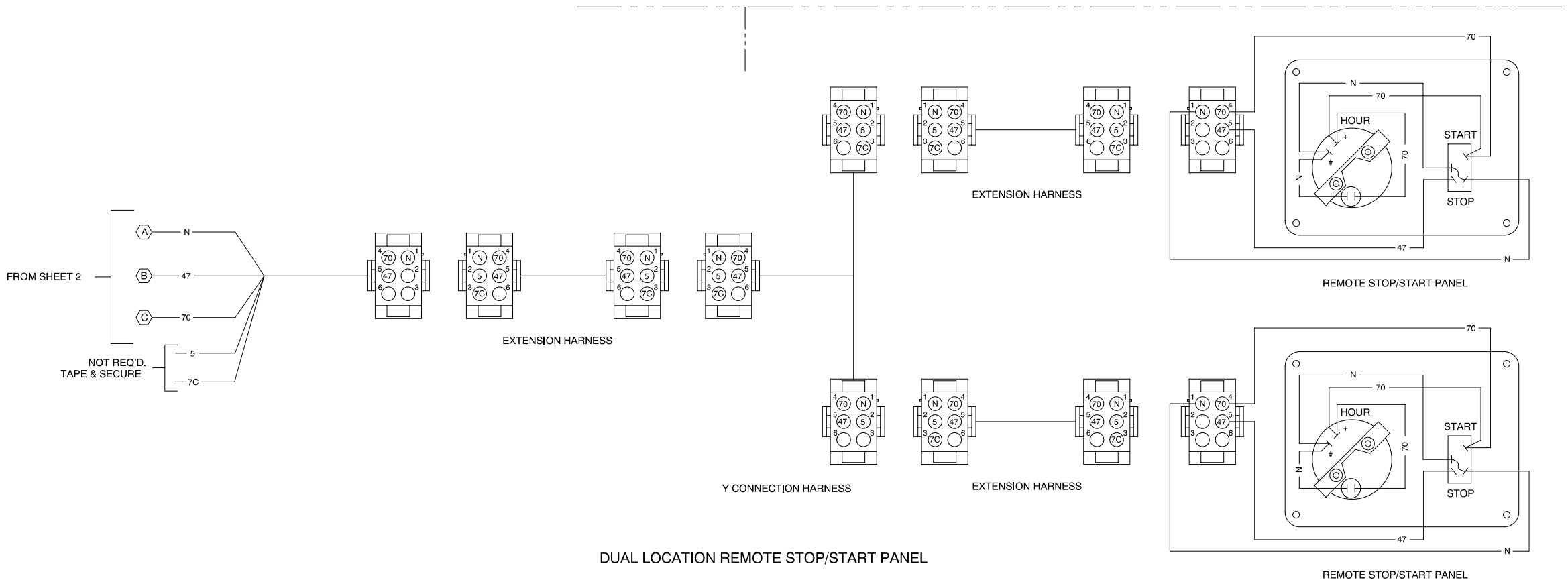


Figure 9-3 Wiring Diagram, Decision-Maker™ 1 Standard Controller, Remote Panel Options (Sheet 3 of 3)

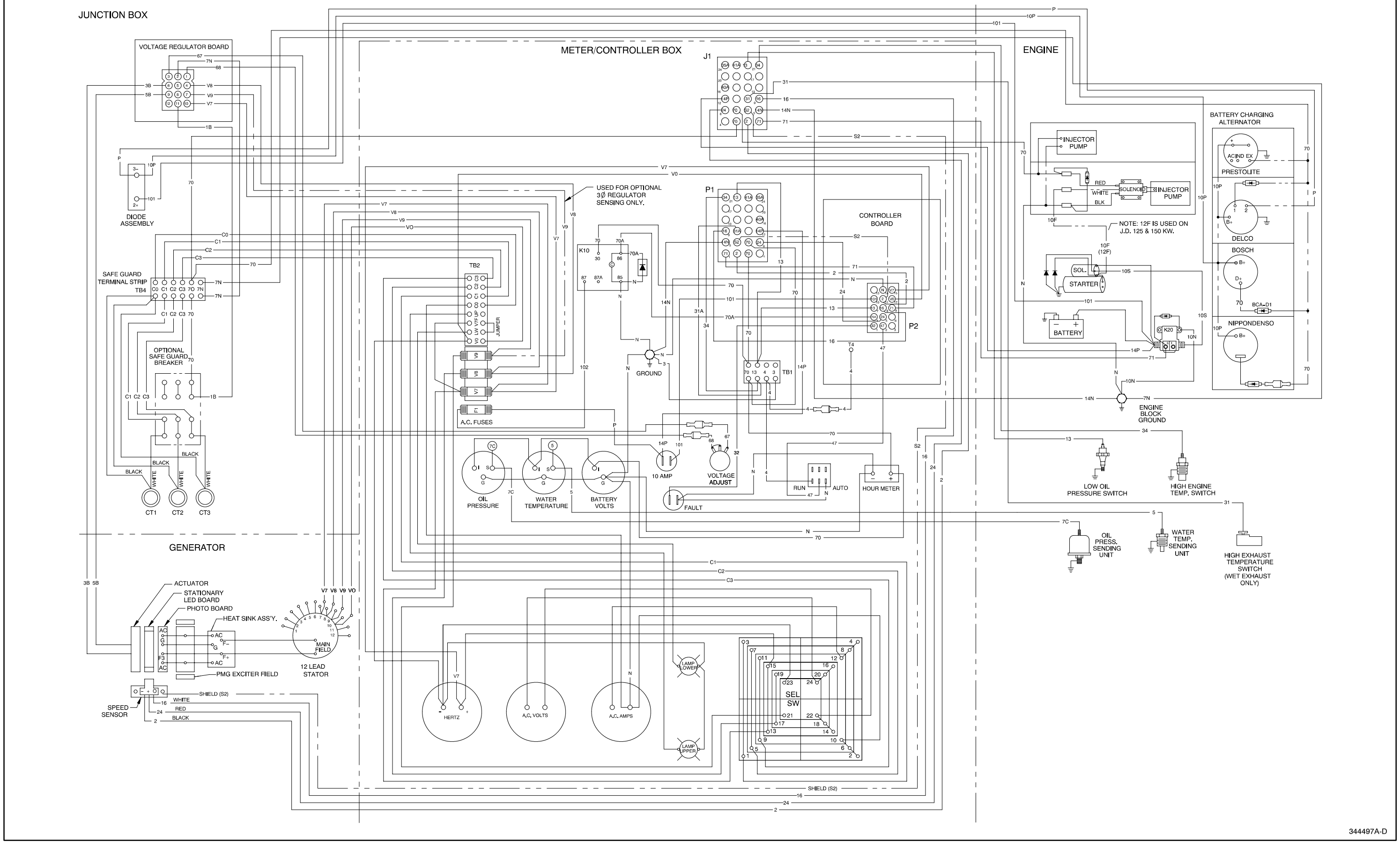


Figure 9-4 Wiring Diagram, Decision-Maker™ 1 Expanded Controller (Sheet 1 of 4)

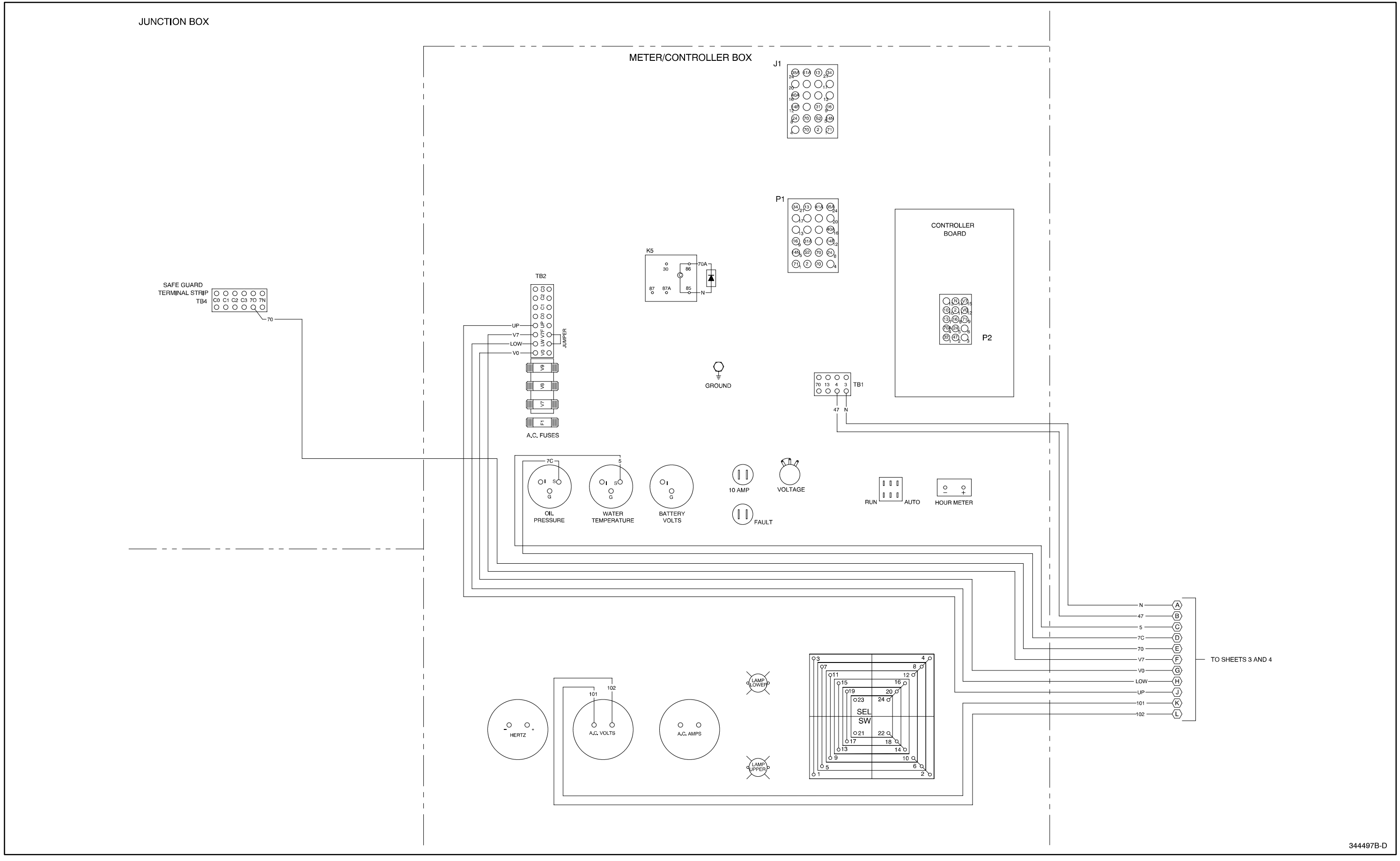
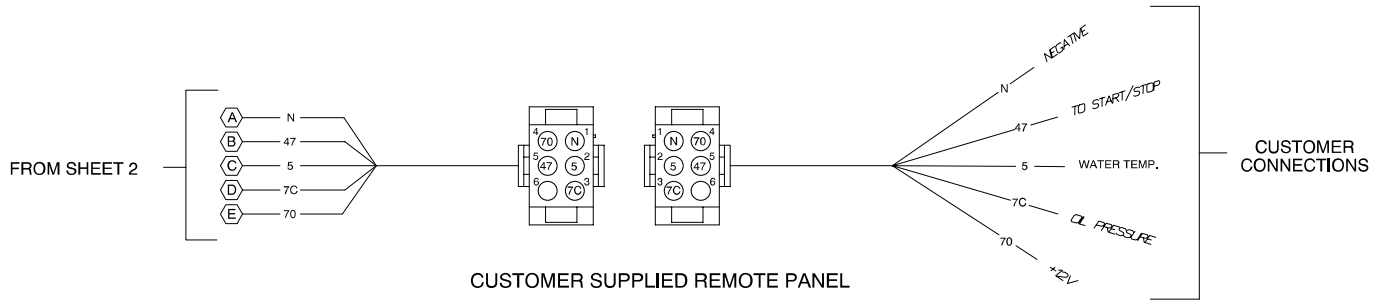
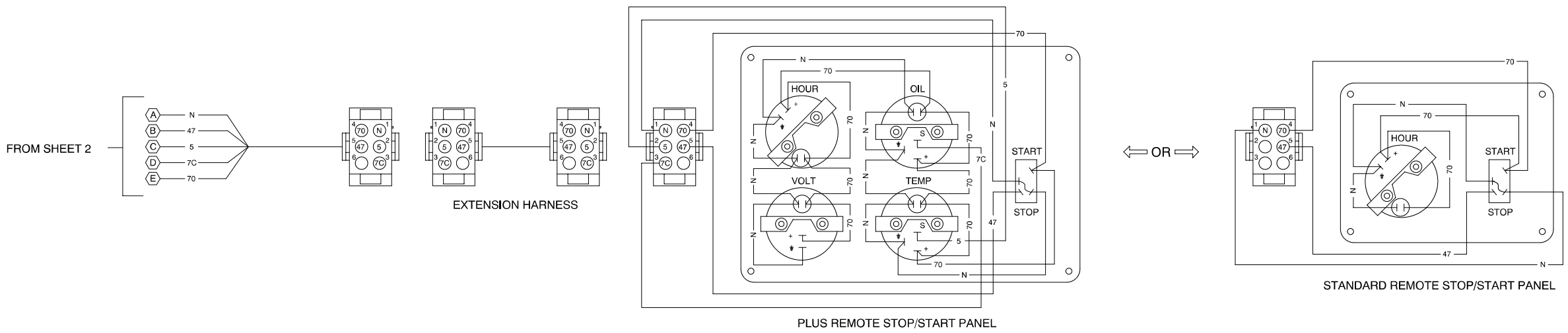


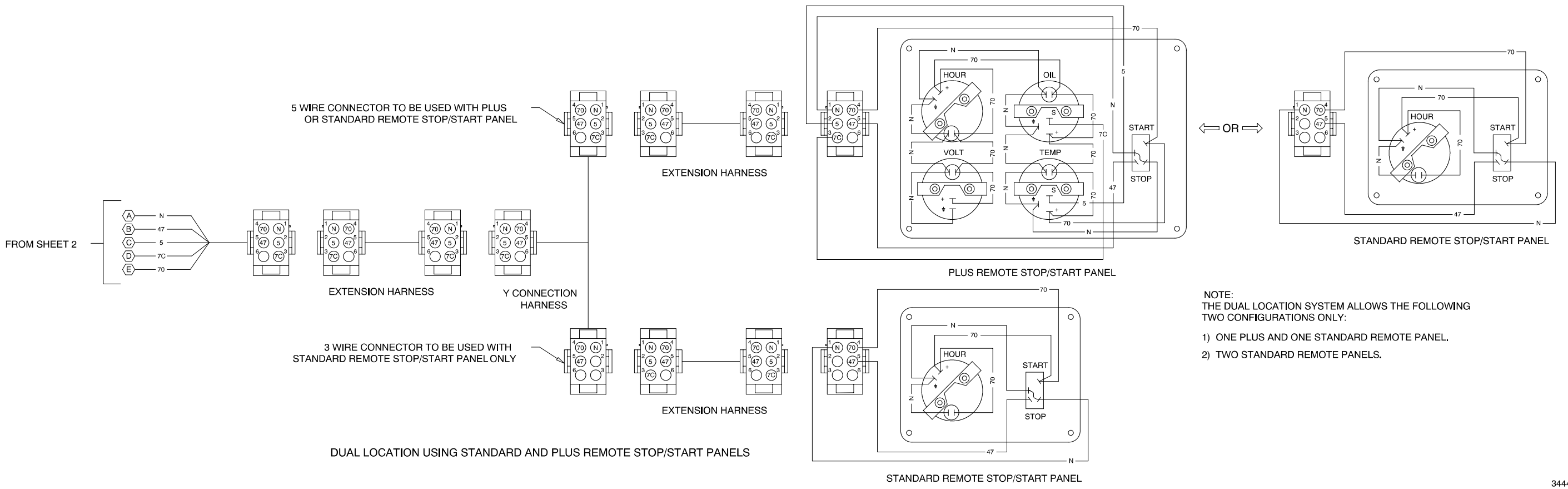
Figure 9-5 Wiring Diagram, Decision-Maker ™ 1 Expanded Controller, Remote Panel Options (Sheet 2 of 4)



CUSTOMER SUPPLIED REMOTE PANEL



REMOTE USING EITHER PLUS OR STANDARD STOP/START PANEL



DUAL LOCATION USING STANDARD AND PLUS REMOTE STOP/START PANELS

Figure 9-6 Wiring Diagram, Decision-Maker ™ 1 Expanded Controller, Remote Panel Options (Sheet 3 of 4)

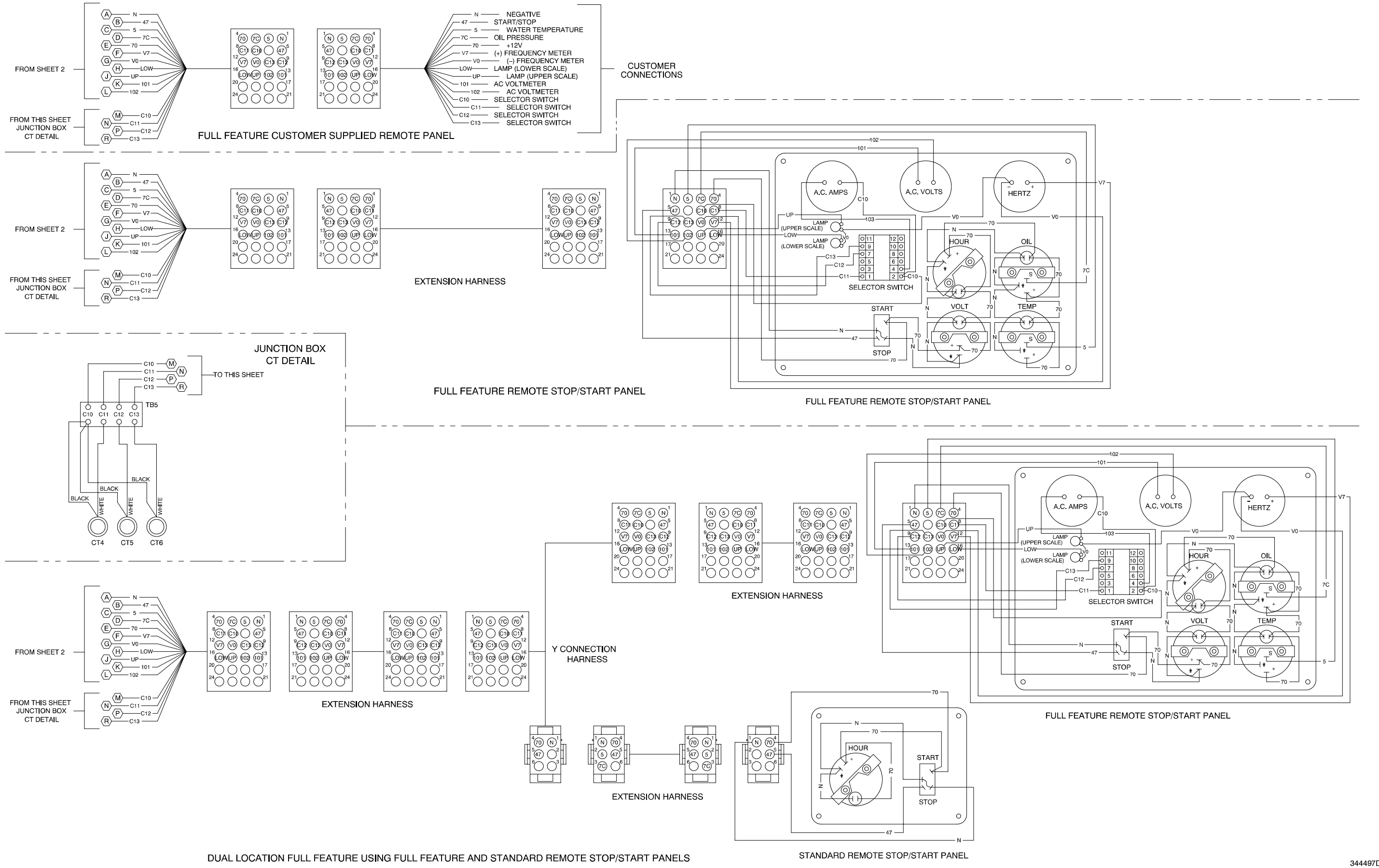


Figure 9-7 Wiring Diagram, Decision-Maker™ 1 Expanded Controller, Remote Panel Options (Sheet 4 of 4)

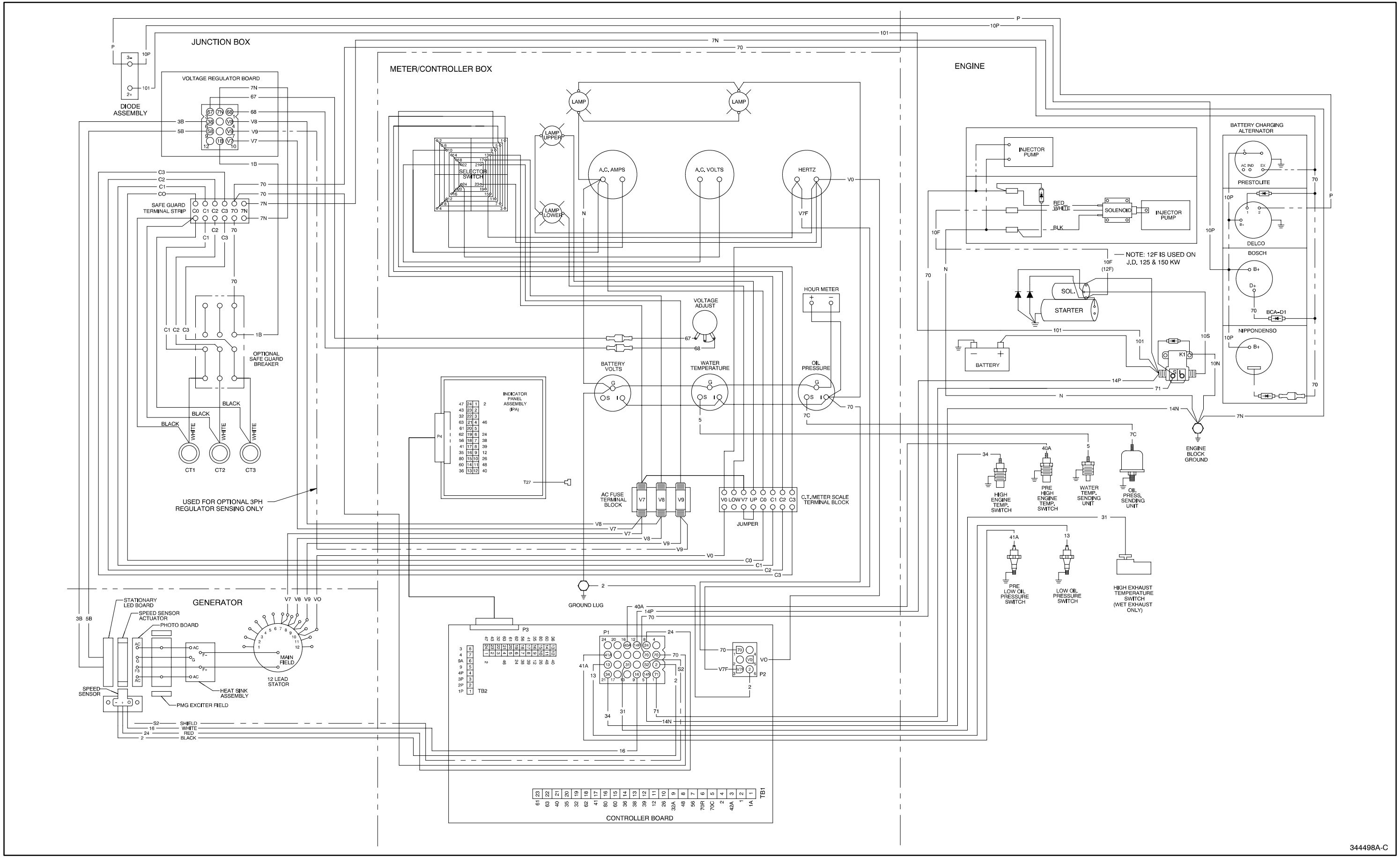


Figure 9-8 Wiring Diagram, Decision-Maker™ 3+ Controller (Sheet 1 of 5)

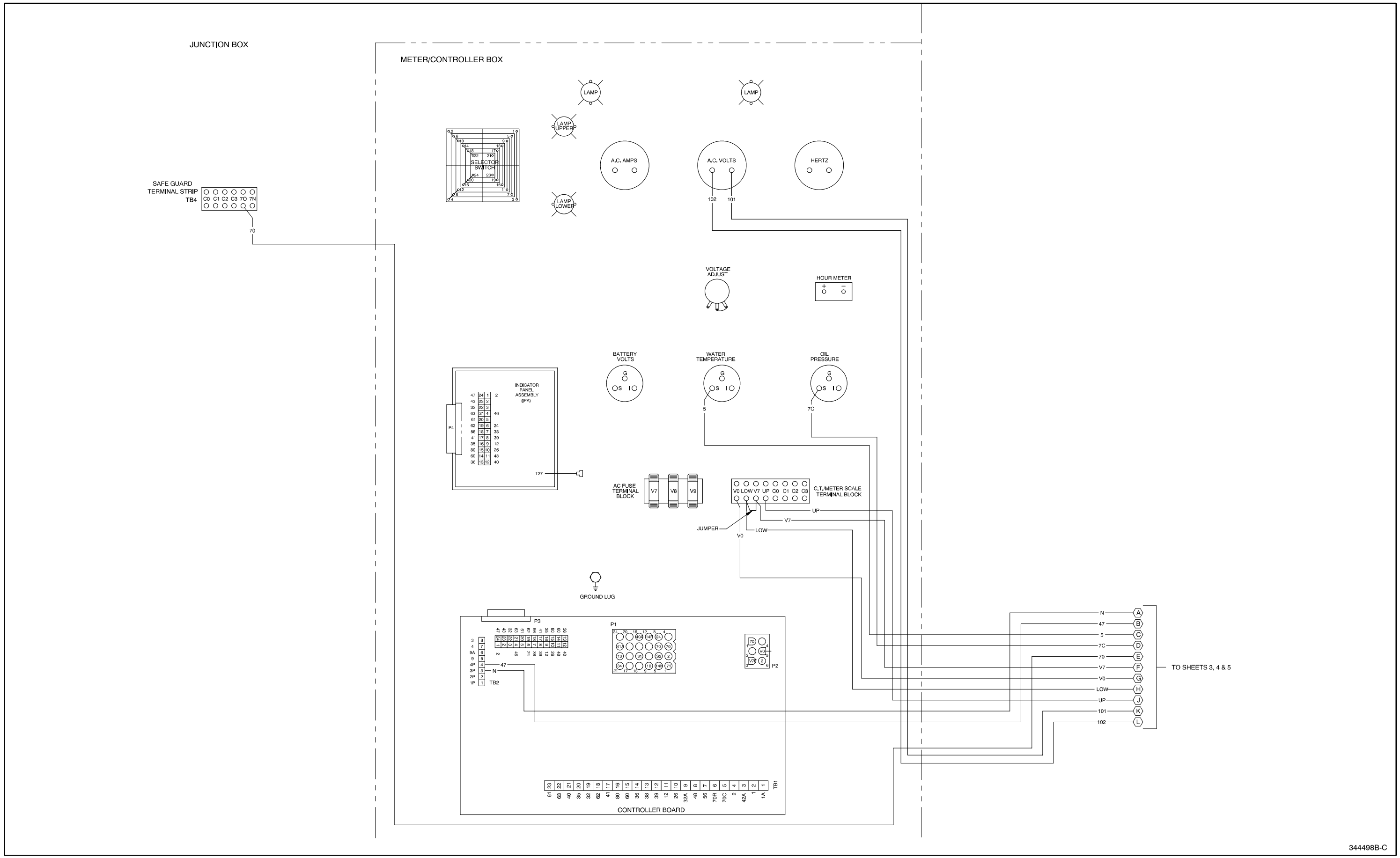
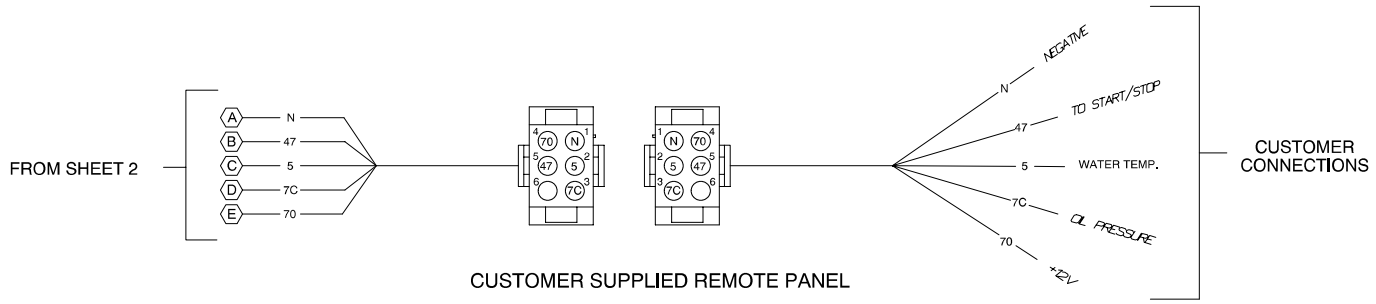
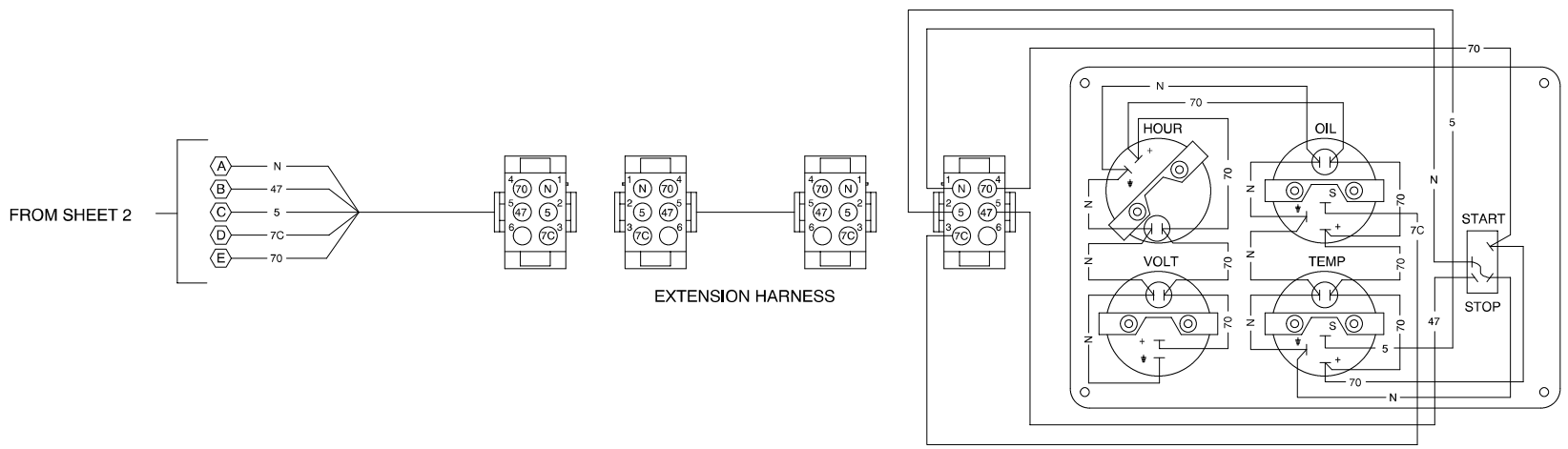


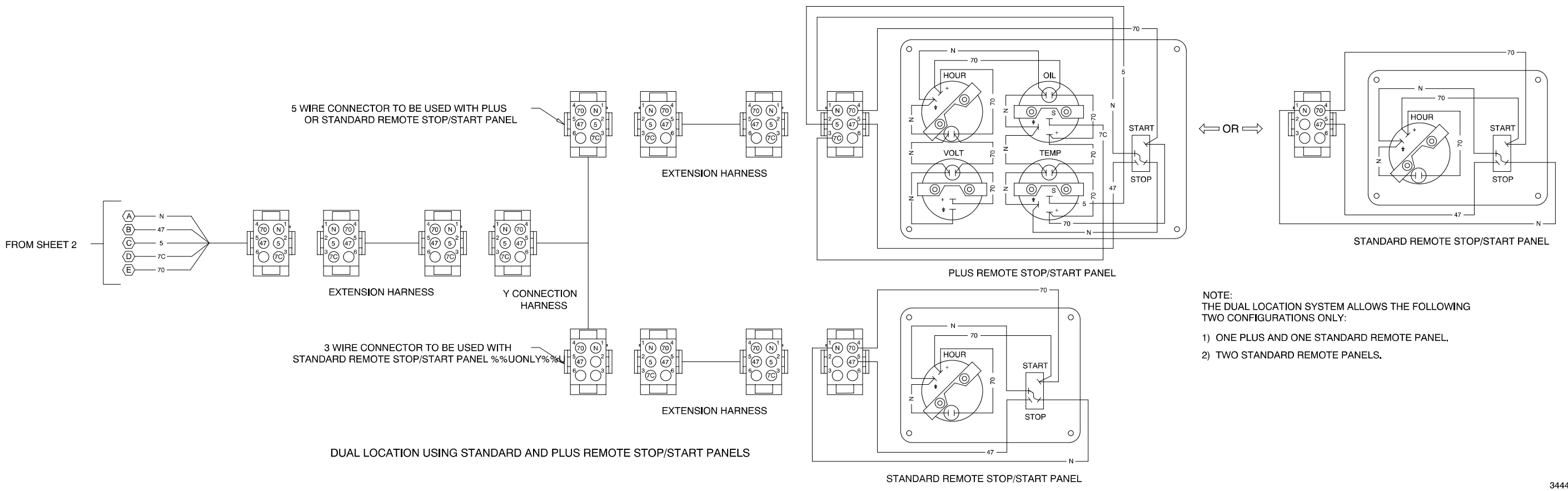
Figure 9-9 Wiring Diagram, Decision-Maker™ 3+ Controller, Remote Panel Options (Sheet 2 of 5)



CUSTOMER SUPPLIED REMOTE PANEL



REMOTE USING EITHER PLUS OR STANDARD STOP/START PANEL



DUAL LOCATION USING STANDARD AND PLUS REMOTE STOP/START PANELS

Figure 9-10 Wiring Diagram, Decision-Maker™ 3+ Controller, Remote Panel Options (Sheet 3 of 5)

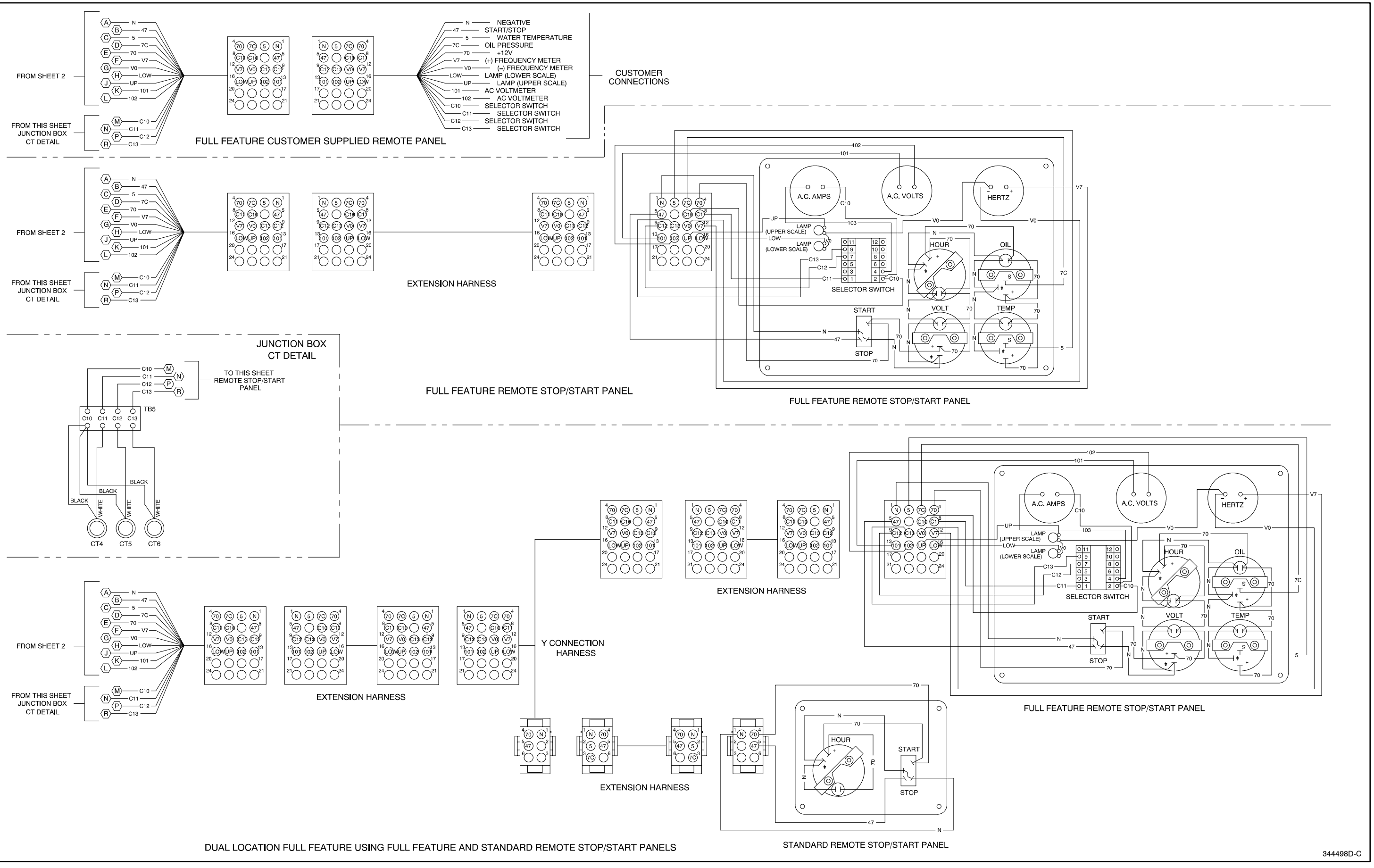


Figure 9-11 Wiring Diagram, Decision-Maker™ 3+ Controller, Remote Panel Options (Sheet 4 of 5)

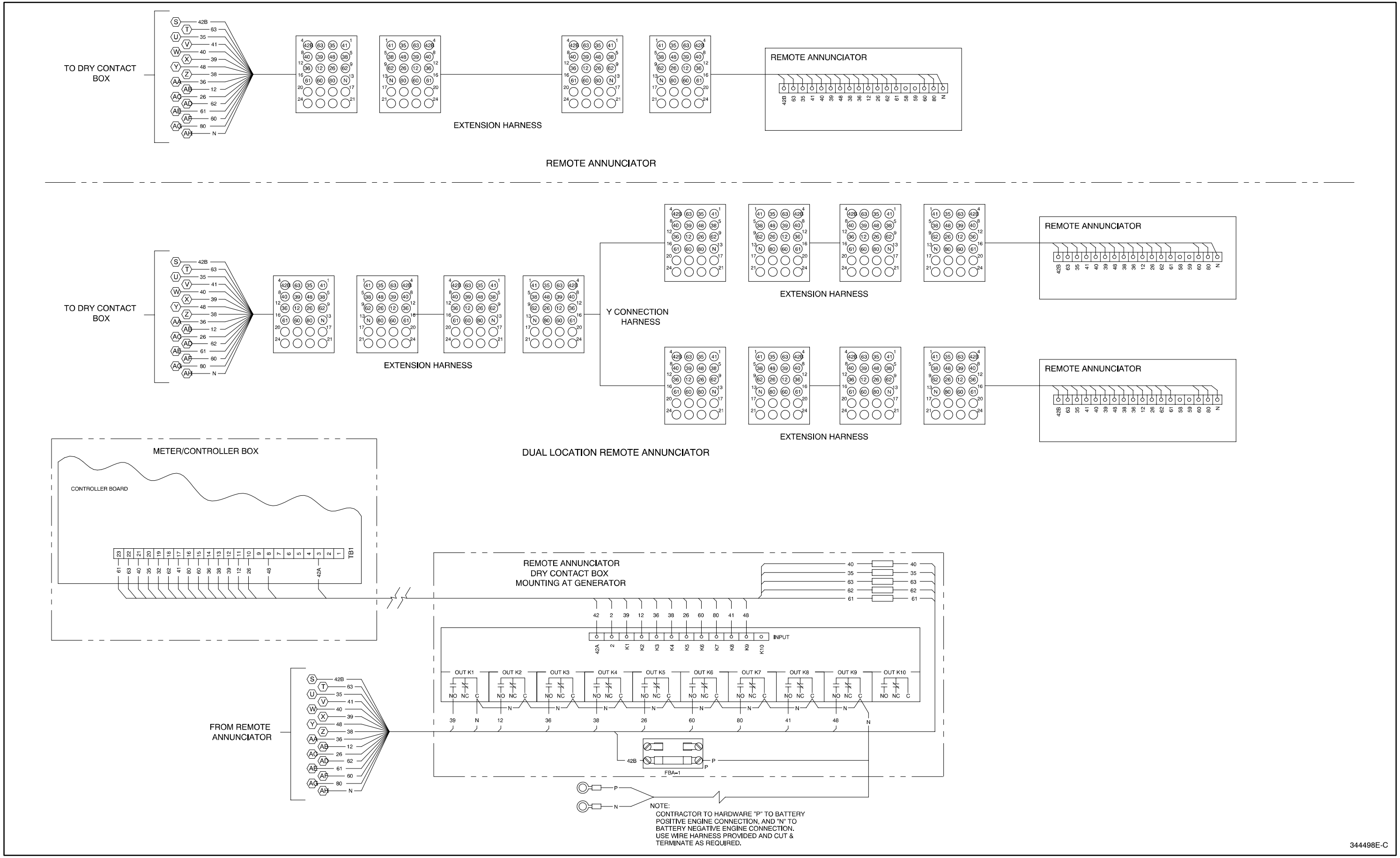
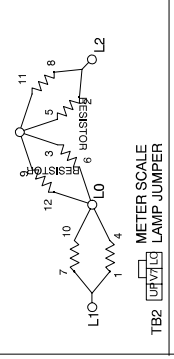


Figure 9-12 Wiring Diagram, Decision-Maker™ 3+ Controller, Remote Panel Options (Sheet 5 of 5)

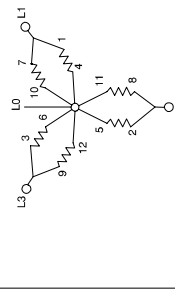
GENERATOR CONNECTIONS

NOTE: CURRENT TRANSFORMER DOT OR HIGH TOWARD GENERATOR

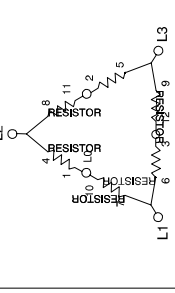
60HZ.–120/240V.–1 PH. 3 WIRE
50HZ.–110/220V.–1 PH. 3 WIRE
USED ON GENERATORS 20KW–100KW ONLY.



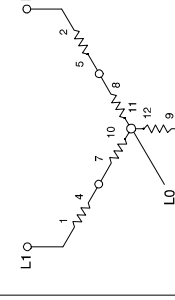
60HZ.–120/208V. OR 139/240V.
3 PH. 4 WIRE LOW WYE
50HZ.–120/208V. OR 110/190V.
3 PH. 4 WIRE LOW WYE



60HZ.–120/240V.–3 PH. 4 WIRE DELTA
50HZ.–110/220V.–3 PH. 4 WIRE DELTA

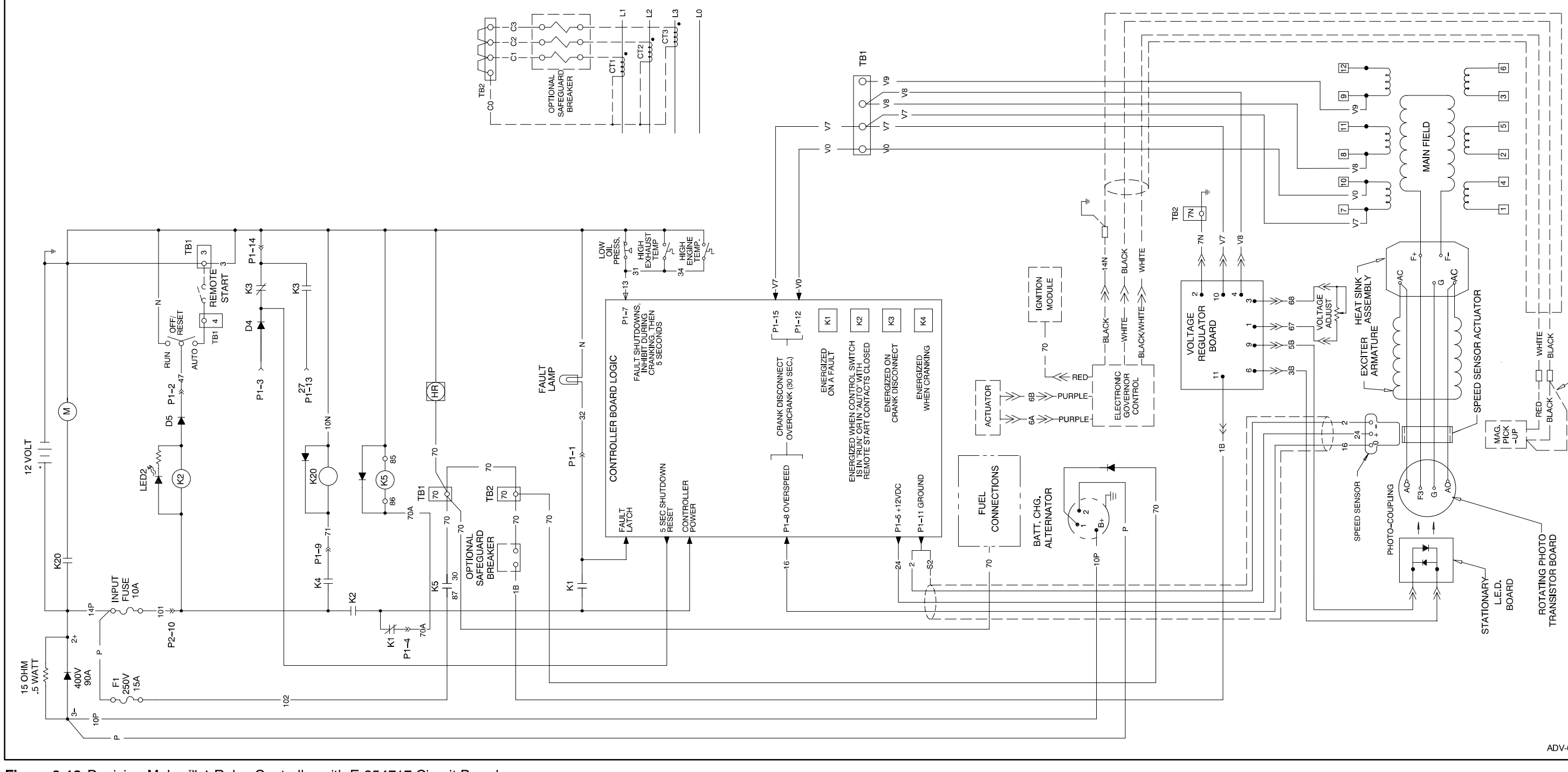


60HZ.–277/480V.–3 PH. 4 WIRE HIGH WYE
50HZ.–220/380V.–3 PH. 4 WIRE HIGH WYE



LEGEND

BV – BATTERY VOLTMETER
F1 – FUSE, 250V, 15A
HR – HOUR METER
K1 – FAULT SHUTDOWN RELAY
K2 – ENGINE RUN RELAY
K3 – CRANK DISCONNECT/ FLASHING CONTROL RELAY
K4 – CRANK DISCONNECT RELAY
K5 – AUX. RUN RELAY
K20 – STARTER RELAY SOLENOID
M – STARTER MOTOR
OP – OIL PRESSURE GAUGE
OPS – OIL PRESSURE SWITCH
TB1 – REMOTE START TERM. BLOCK
TB2 – SAFEGUARD BRAKER TERM. BLOCK
– – USED ON FORD LSG-875 ENGINE ONLY



ADV-6120-A

Figure 9-13 Decision-Maker™ 1 Relay Controller with E-254717 Circuit Board

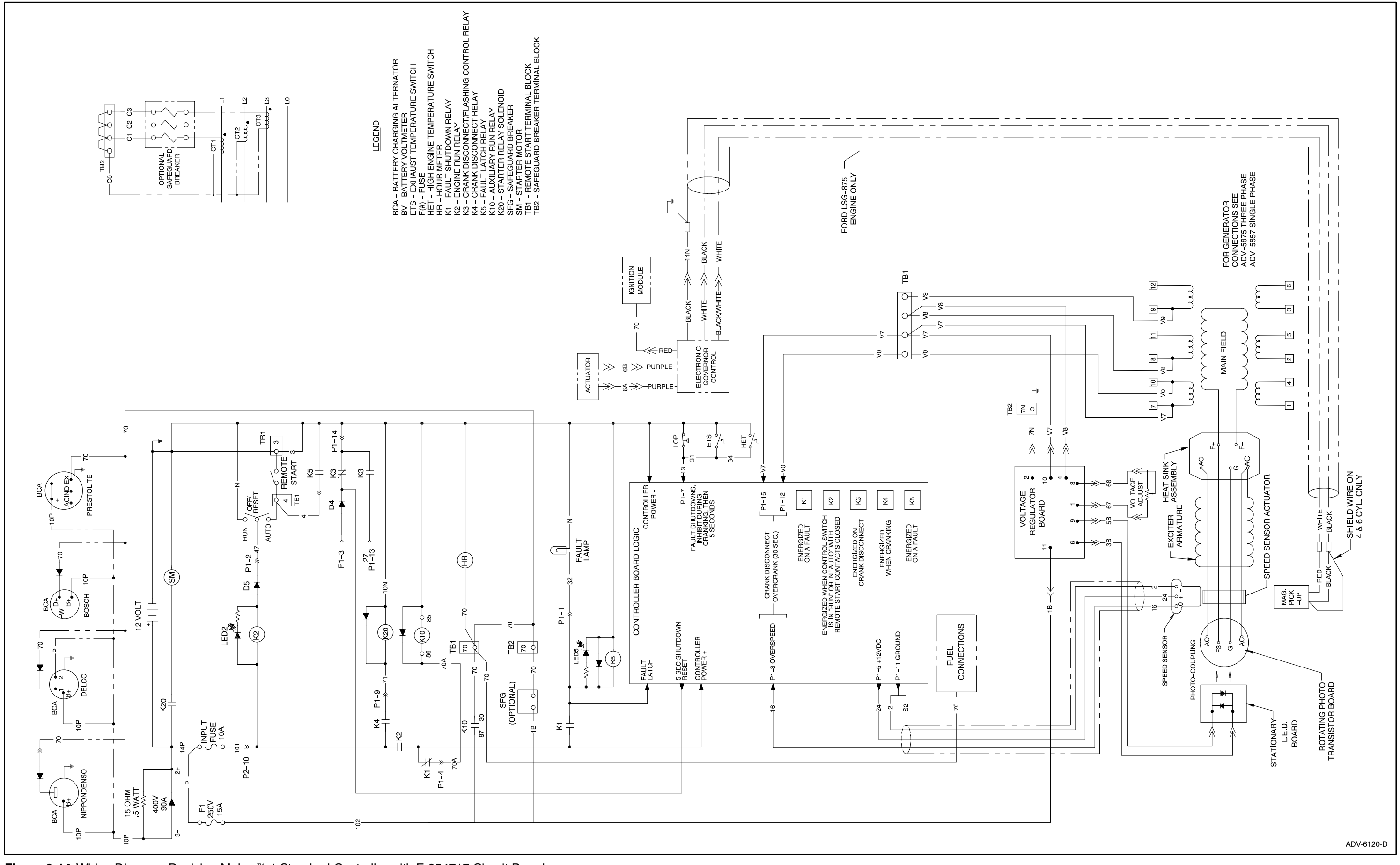


Figure 9-14 Wiring Diagram, Decision-Maker™ 1 Standard Controller with F-254717 Circuit Board

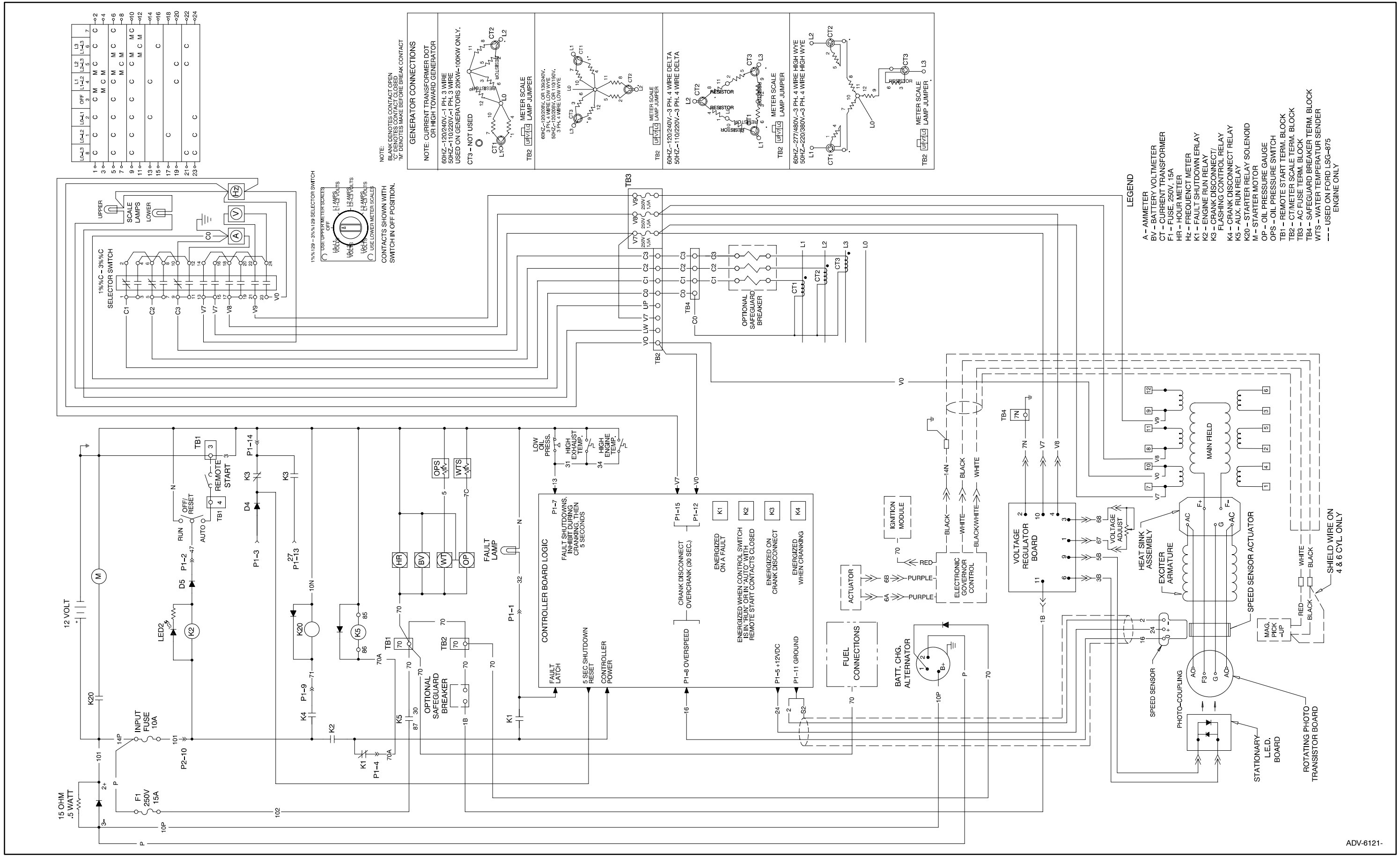


Figure 9-15 Decision-Maker™ 1 Expanded Relay Controller with E-254717 Circuit Board

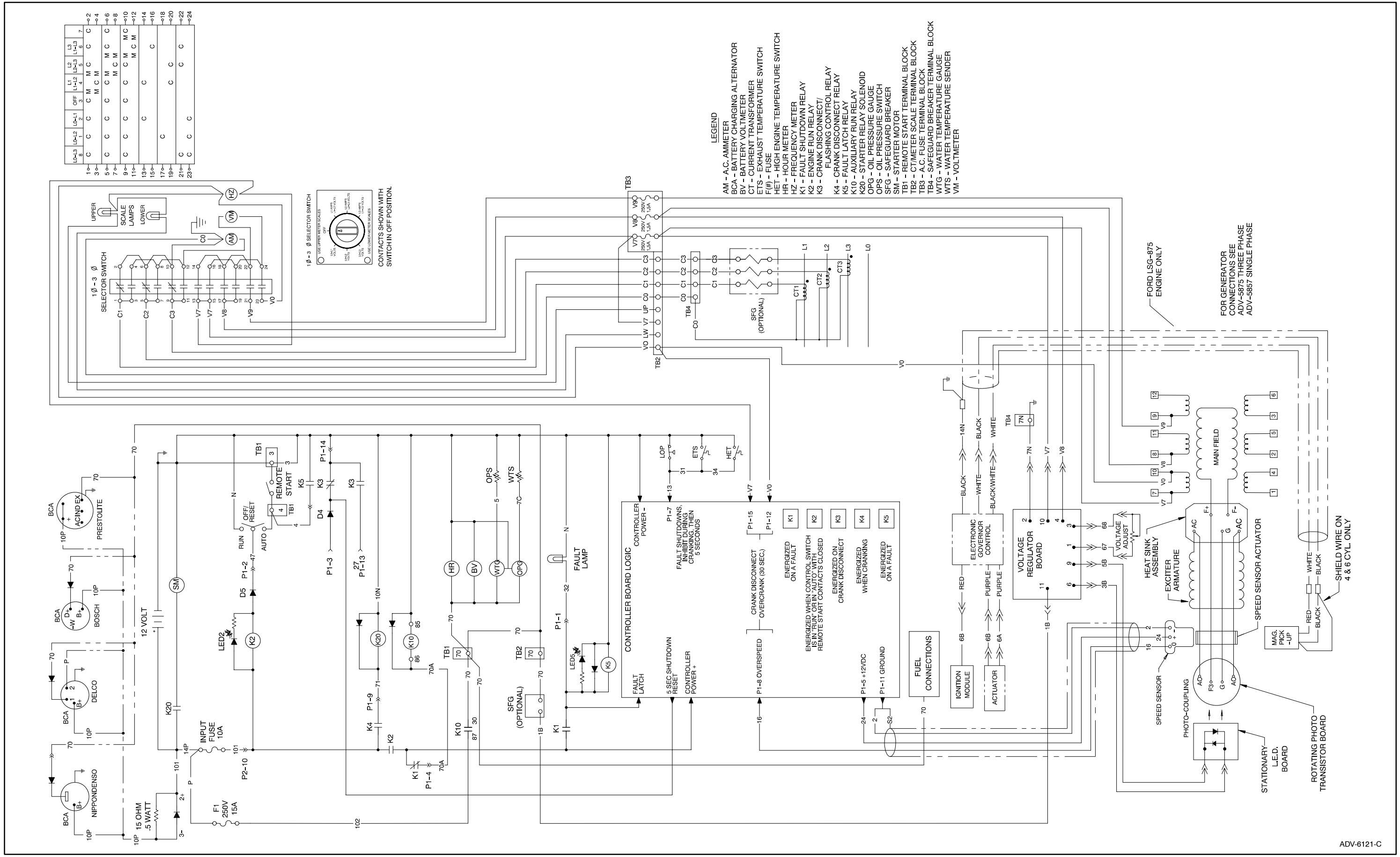


Figure 9-16 Wiring Diagram, Decision-Maker™ 1 Expanded Controller with F-254717 Circuit Board

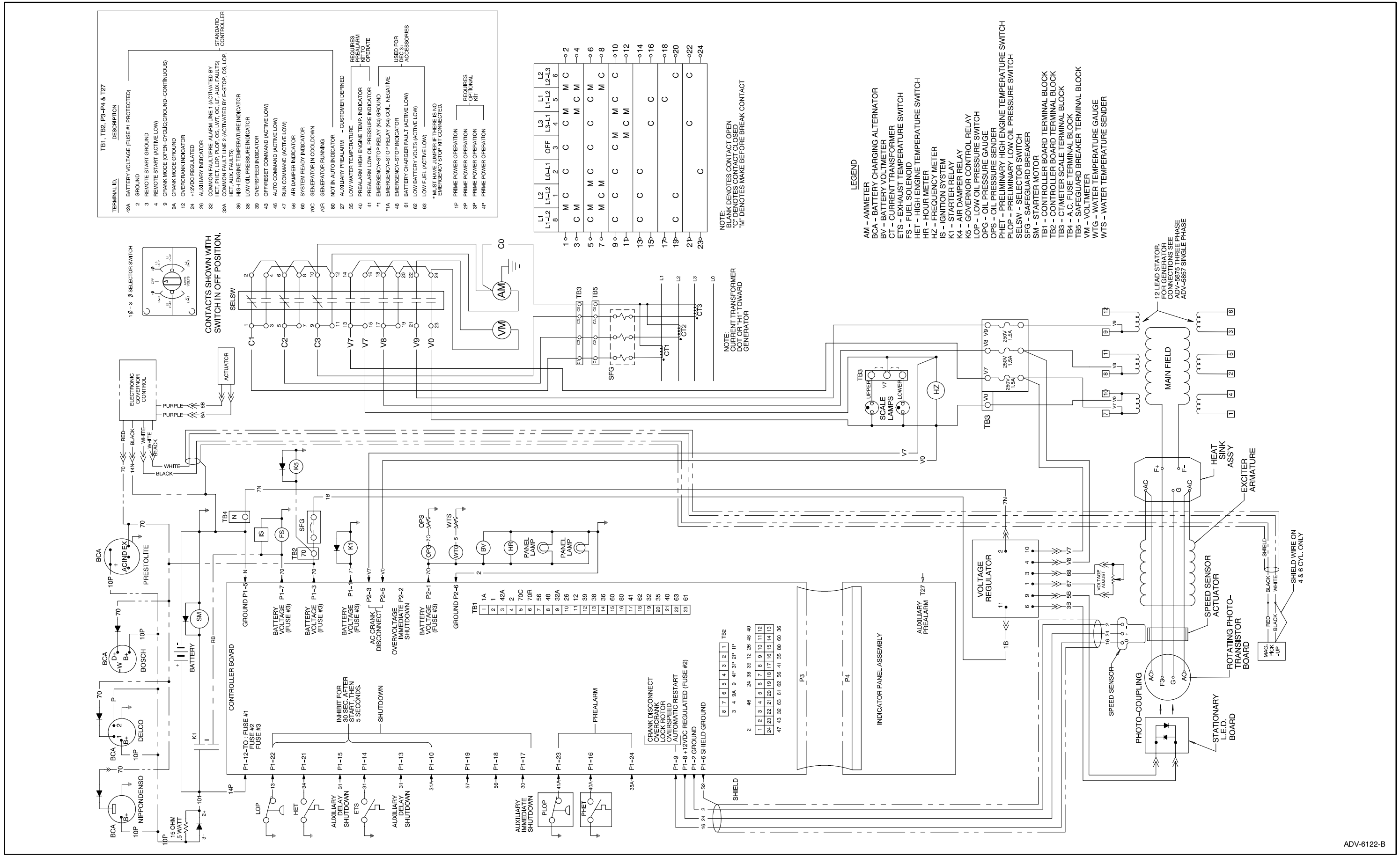


Figure 9-17 Wiring Diagram, Decision-Maker™ 3+ Controller

Notes

Terminal	Purpose
1	Ground—emergency stop relay (K4)—connect emergency stop across terminals TB1-1 and 1A *
1A	Emergency stop relay (K4) coil; negative side—connect emergency stop across terminals TB1-1 and 1A *
2	Ground terminal
12	Overcrank (OC) signal †
26	Auxiliary (AUX) signal †
32	Common fault/prealarm line 1—A/V alarm or common fault relay activated by OC, 12; AUX, 26; LWT, 35; HET, 36; LOP, 38; OS, 39; AHET, 40; ALOP, 41; and LF, 63 faults
32A	Common fault/prealarm line 2—A/V alarm or common fault relay activated by AUX, 26; HET, 36; LOP, 38; OS, 39; and ES, 48 faults
35	Low water temperature (LWT) signal
36	High engine temperature (HET) signal †
38	Low oil pressure (LOP) signal †
39	Overspeed (OS) signal †
40	Anticipatory high engine temperature (AHET) signal †
41	Anticipatory low oil pressure (ALOP) signal †
42A	Battery voltage (fuse #1 protected)—accessory power supply; customer may also provide separate accessory power source
48	Emergency stop (ES) signal †
56	Air damper (AD) switch, if equipped
60	System ready signal †
61	Battery charger fault—connect battery charger alarm contact to TB1-61 to activate fault lamp (active low), if used
62	Low battery volts—connect battery charger alarm contact to TB1-62 to activate fault lamp (active low), if used
63	Low fuel (LF) fault—connect fuel level sensor to TB1-63 to activate fault lamp (active low), if used
70C	Generator in cool down mode signal
70R	Generator in running mode signal
80	Not in auto signal †

* Connect jumper across terminals 1 and 1A if emergency stop switch is not used.

† Use a remote annunciator and/or A/V alarm kit as an indicator with a dry contact kit connected to controller terminal strip TB1.

Note: Not all terminals are used for all generator sets (see appropriate wiring diagrams for specific generator set model).

Figure 9-18 Controller TB1 Terminal Strip (Decision-Maker™ 3+ Controller)

Terminal	Purpose
1P	Prime power operation
2P	Prime power operation
3	Remote start ground—connect transfer switch or remote start switch to TB2-3 and TB2-4
3P	Prime power operation
4	Remote start—connect transfer switch or remote start switch to TB2-3 and TB2-4
4P	Prime power operation
9	Crank mode selection (open: cyclic crank, ground: continuous crank); connect TB2-9 to TB2-9A for continuous cranking; leave TB2-9 open cyclic cranking; see starting instructions in Section 2, Operation.
9A	Crank mode ground

Note: To use prime power mode—place jumpers across TB2-1P to TB2-2P, TB2-3P to TB2-4P, and TB2-3 to TB2-4. To deactivate prime power mode—remove jumpers across TB2-1P to TB2-2P, TB2-3P to TB2-4P, and TB2-3 to TB2-4.

Figure 9-19 Controller TB2 Terminal Strip (Decision-Maker™ 3+ Controller)

9.1 Voltage Reconnection

9.1.1 Introduction

Use the following voltage reconnection procedure to change the voltage of 12-lead generator sets. See Generator Set Frequency Change and Adjustment later in this section for frequency adjustment information.

Refer to 9.1.2, Voltage Reconnection Procedure and the connection schematics. Follow the safety precautions at the front of this manual and in the procedure text and observe National Electrical Code (NEC) guidelines.

NOTICE

Voltage reconnection. Affix a notice to the generator set after reconnecting the set to a voltage different from the voltage on the nameplate. Order voltage reconnection decal 246242 from an authorized service distributor/ dealer.

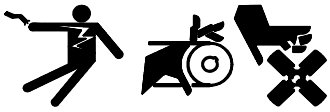
NOTICE

This generator set has been rewired from its nameplate voltage to

246242

Note: Equipment damage. Verify that the voltage ratings of the transfer switch, line circuit breakers, and other accessories match the desired line voltage.

⚠ WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

⚠ WARNING

Hazardous voltage. Moving rotor.
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

Grounding electrical equipment. Hazardous voltage can cause severe injury or death. Electrocution is possible whenever electricity is present. Open the main circuit breakers of all power sources before servicing the equipment. Configure the installation to electrically ground the generator set, transfer switch, and related equipment and electrical circuits to comply with applicable codes and standards. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage**.** Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

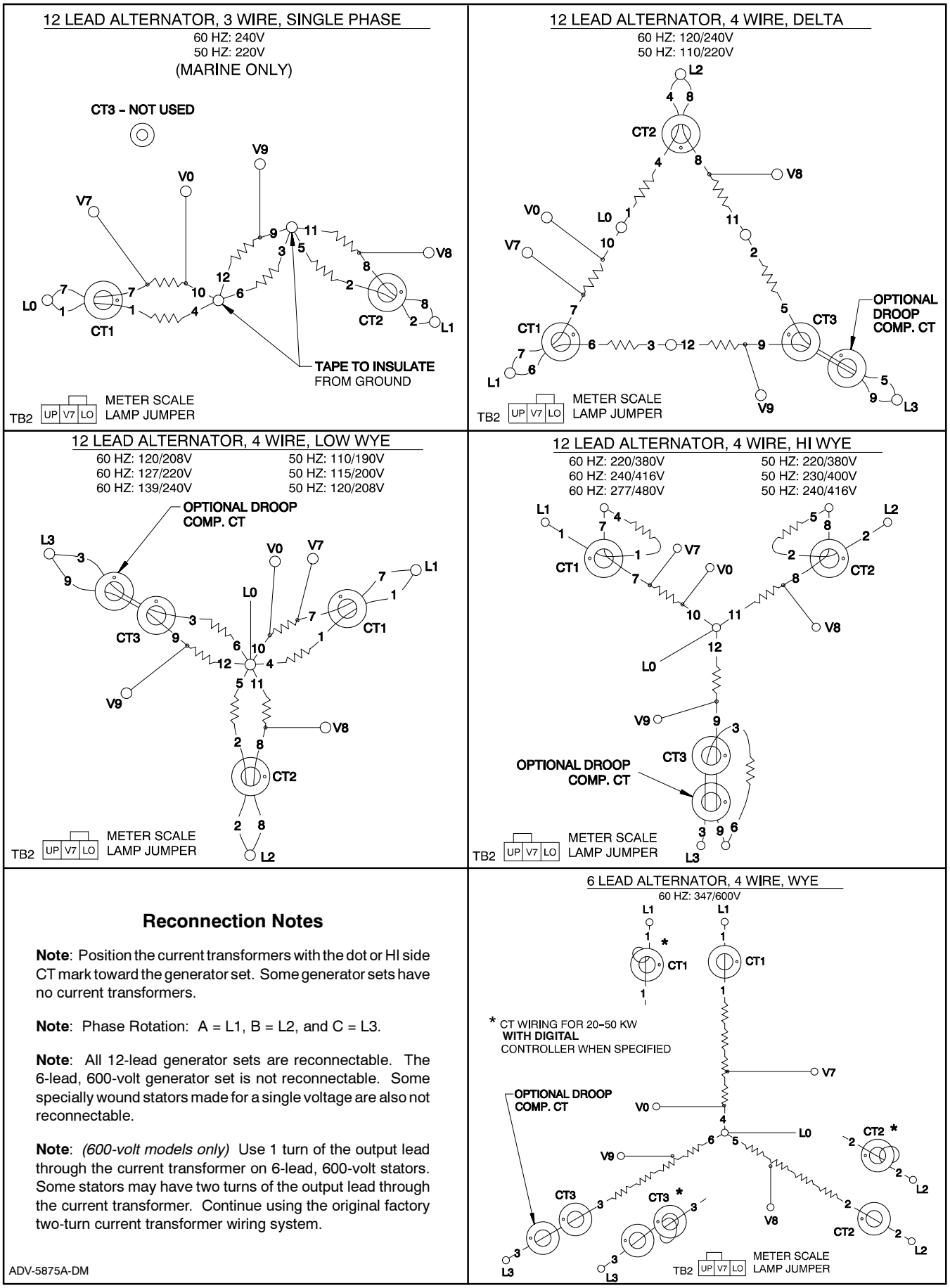
x:gr:001:001

9.1.2 Voltage Reconnection Procedure

1. Place the generator set master switch in the OFF/RESET position.

2. Disconnect the generator set engine starting battery, negative (-) lead first. Disconnect power to the battery charger (if equipped).

3. Use Figure 9-20 or Figure 9-21 to determine the generator set voltage configuration. Note the original voltage and reconnect as needed. Route leads through current transformers (CTs) and connect them according to the diagram for desired phase and voltage.



Reconnection Notes

Note: Position the current transformers with the dot or HI side CT mark toward the generator set. Some generator sets have no current transformers.

Note: Phase Rotation: A = L1, B = L2, and C = L3.

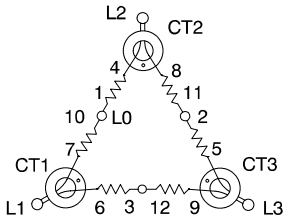
Note: All 12-lead generator sets are reconnectable. The 6-lead, 600-volt generator set is not reconnectable. Some specially wound stators made for a single voltage are also not reconnectable.

Note: *(600-volt models only)* Use 1 turn of the output lead through the current transformer on 6-lead, 600-volt stators. Some stators may have two turns of the output lead through the current transformer. Continue using the original factory two-turn current transformer wiring system.

ADV-5875A-DM

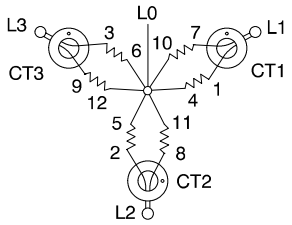
Figure 9-20 Generator Set Reconnections Sheet 1

3 PHASE DELTA, 4 WIRE



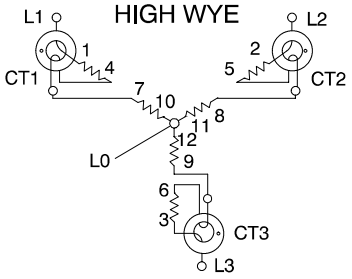
110/220 VOLT 50 HZ
120/240 VOLT 60 HZ

3 PHASE WYE, 4 WIRE
LOW WYE



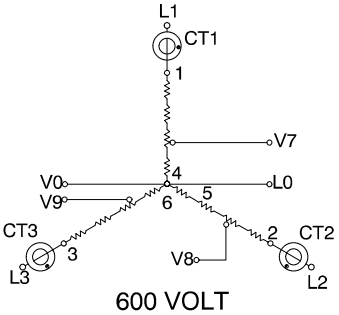
190–208 VOLT 50 HZ
208–240 VOLT 60 HZ

3 PHASE WYE, 4 WIRE
HIGH WYE



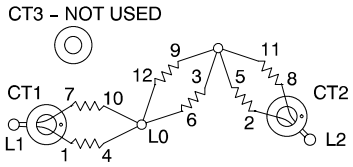
380–416 VOLT 50 HZ
416–480 VOLT 60 HZ

3 PHASE WYE 4 WIRE



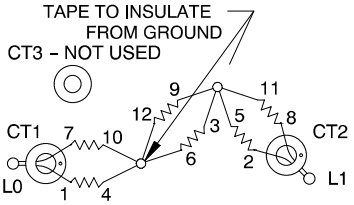
600 VOLT

SINGLE PHASE, 3 WIRE
SOME SETS NOT RATED FOR
SINGLE PHASE – SEE MANUALS



110/220 VOLT 50 HZ
120/240 VOLT 60 HZ

SINGLE PHASE, 2 WIRE
(MARINE ONLY)



220 VOLT 50 HZ
240 VOLT 60 HZ

Reconnection Notes

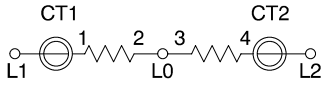
Note: Position the current transformers with the dot or HI side CT mark toward the generator set. Some generator sets have no current transformers.

Note: Phase Rotation: A = L1, B = L2, and C = L3.

Note: All 12-lead generator sets are reconnectable. The 6-lead, 600-volt generator set is not reconnectable. Some specially wound stators made for a single voltage are also not reconnectable.

EM-250000-G

SINGLE PHASE, 3 WIRE



(NOT RECONNECTABLE)

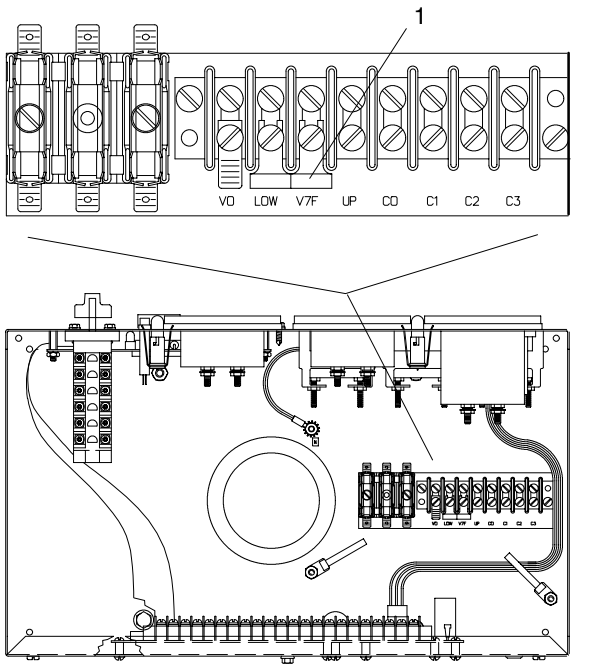
60 HZ 120/240V 1 PH. 3 WIRE
50 HZ 110/220V OR 115/230V
1 PH. 3 WIRE

Figure 9-21 Generator Set Reconnections Sheet 2

Note: Position the current transformers with the dot or HI side CT marking toward the generator set.

Note: Only generator sets equipped with AC meter controllers and/or safeguard circuit breakers require CTs.

4. If the controller has meters, remove the controller cover and reposition the meter scale lamp jumper (see Figure 9-22) matching the position of the desired voltage (shown in Figure 9-20 or Figure 9-21).



1. Lamp jumper

Figure 9-22 Meter Scale Lamp Jumper

5. The overvoltage shutdown is standard on Decision-Maker™ 3+ controllers. The **139/240 volt (low wye)** and **277/480 volt (high wye)**, 3-phase, 4-wire, 60 Hz configurations use different overvoltage shutdown settings than all other configurations. Recalibrate the overvoltage shutdown if the reconnection changes the voltage to or from one of these configurations. See Section 9.2, Overvoltage Shutdown Adjustment. Do not recalibrate the overvoltage adjustment for other voltage changes.

6. If the controller has meters, set the phase selector switch to the L1-L2 position (1-phase or 3-phase configuration depending on generator set connection). Connect a voltmeter across leads L1 and L2 if the controller has no meters.

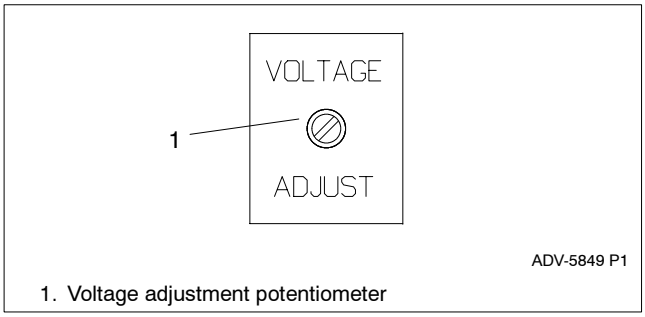
   Note: Equipment damage. Verify that the voltage ratings of the transfer switch, line circuit breakers, and other accessories match the desired line voltage.

7. Reconnect the starting battery, negative (–) lead last. Place the generator set master switch in the RUN position to start the generator set. Observe the voltmeter and verify that the unit has the desired line voltage.

   Adjust the voltage using the voltage adjustment potentiometer on the generator controller front panel. See Figure 9-23.

8. Stop the generator set after completing the voltage adjustment.

9. Disconnect the external voltmeter if used. Replace the controller cover.



1. Voltage adjustment potentiometer

Figure 9-23 Voltage Adjustment Potentiometer on Controller

x:gr:001:002:a

9.2 Overvoltage Shutdown Adjustment

The 139/240 volt (low wye) and 277/480 volt (high wye), 3-phase, 4-wire, 60 Hz configurations use different overvoltage shutdown settings than all other configurations. Recalibrate the overvoltage shutdown if the reconnection changes the voltage to or from one of these configurations. **Do not recalibrate the overvoltage adjustment for other voltage changes.**

Disconnecting the electrical load. Hazardous voltage can cause severe injury or death. Disconnect the generator set from the load by opening the line circuit breaker or by disconnecting the generator set output leads from the transfer switch and heavily taping the ends of the leads. High voltage transferred to the load during testing may cause personal injury and equipment damage. Do not use the safeguard circuit breaker in place of the line circuit breaker. The safeguard circuit breaker does not disconnect the generator set from the load.

Short circuits. Hazardous voltage/current can cause severe injury or death. Short circuits can cause bodily injury and/or equipment damage**.** Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

Overvoltage Shutdown Adjustment Procedure

1. Disconnect the generator set engine starting battery, negative (–) lead first. Disconnect power to the battery charger (if equipped).

2. With the generator set shut down, open the output line circuit breaker to disconnect the load from the generator set.

3. Remove the controller cover.

4. Wrap the shaft of an insulated-handle screwdriver with electrical tape to insulate the metal shaft. Turn the overvoltage potentiometer (R41) on the main circuit board fully clockwise. See Figure 9-24.

5. Connect a digital AC voltmeter (or other 1% minimum accuracy voltmeter) to terminals V0 and V7F (or V7) on the controller terminal block. See Figure 9-22.

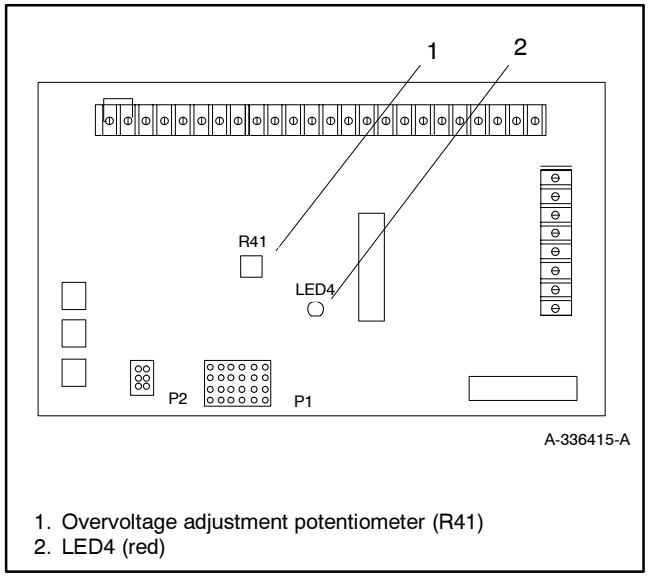
6. Reconnect the battery, negative (–) lead last.

7. Start the generator set by placing the generator set master switch in the RUN position.

8. Adjust the output voltage to 115% of the nominal output voltage using the voltage adjustment potentiometer. If the voltage configuration is 139/240 volts (low wye) or 277/480 volts (high wye), 3-phase, 4-wire, 60 Hz, adjust the output voltage to 160 volts across terminals V0 and V7F (or V7). For all other voltages, adjust the output voltage to 115% of the nominal output voltage measured across terminals V0 and V7F (or V7).

   Adjust the voltage using the voltage adjustment potentiometer on the generator controller front panel. See Figure 9-23.

9. Use the insulated screwdriver to slowly rotate the overvoltage adjustment potentiometer (R41) counterclockwise until red LED4 lights. See Figure 9-24. The generator set should shut down on an overvoltage fault in approximately 2 seconds.



1. Overvoltage adjustment potentiometer (R41)
2. LED4 (red)

Figure 9-24 Overvoltage Shutdown Adjustment on Main Circuit Board

10. Turn the voltage adjustment potentiometer counterclockwise to prevent overvoltage shutdown upon restart. Restart the generator set. Slowly increase the voltage by turning the voltage adjustment potentiometer clockwise. Verify the shutdown voltage point (115% of the nominal output voltage) by observing the voltmeter and noting when LED4 lights. The generator set should shut down on overvoltage fault in approximately 2 seconds. If the shutdown voltage point is not 115% of nominal voltage, repeat the calibration procedure; otherwise, continue to step 11.

11. Turn the voltage adjustment potentiometer counterclockwise to prevent overvoltage shutdown upon restart. Restart the generator set. Readjust the generator set output to the nominal voltage using the voltage adjustment potentiometer.

12. Stop the generator set by placing the generator set master switch in the OFF/RESET position. Seal the overvoltage adjustment potentiometer (R41) with RTV sealant or equivalent. Replace the controller cover.

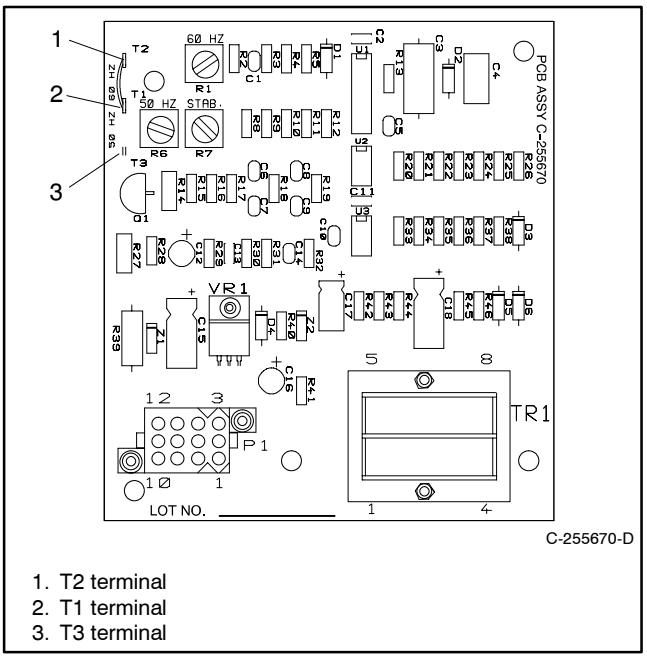
x:gr:001:003

9.3 Generator Set Frequency Change and Adjustment

9.3.1 Frequency Change

Set the voltage regulator circuit board for either 50 or 60 Hz application. See Figure 9-25. Connect a jumper between terminals T1 and T2 for 60 Hz operation. Connect a jumper between terminals T1 and T3 to convert voltage regulator circuit board to 50 Hz application.

This procedure changes the voltage regulator circuit board for the desired frequency. See Frequency Adjustment for changing generator set frequency and speed.



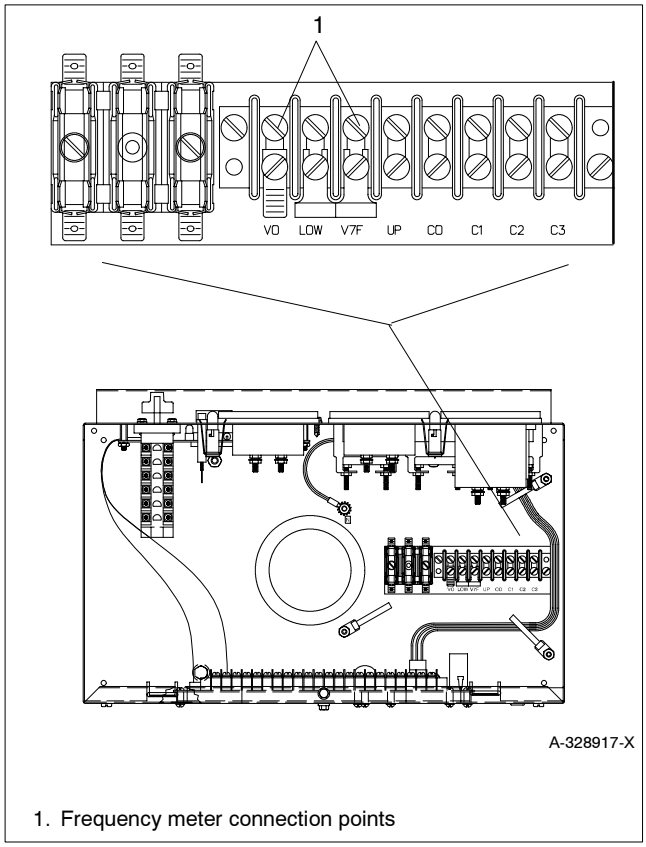
1. T2 terminal
2. T1 terminal
3. T3 terminal

Figure 9-25 Jumper Location for 50 or 60 Hz Operation

9.3.2 Frequency Adjustment

Check the frequency meter for a no-load reading of 63 Hz for 60 Hz operation and 53 Hz for 50 Hz operation to determine correct frequency operation. Check for 50 and 60 Hz operation at no load if the generator set is equipped with an isochronous governor. Connect a frequency meter across V0 and V7 on the control board terminal strip (generator set must not be running while making connections) if the controller is not equipped with a frequency meter. Refer to Figure 9-26.

To adjust governor speed, refer to Section 7, Component Testing and Adjustment, Governors.



1. Frequency meter connection points

Figure 9-26 Frequency Meter Connections

Notes

Appendix A Abbreviations

The following list contains abbreviations that may appear in this publication.

A, amp	ampere
ABDC	after bottom dead center
AC	alternating current
A/D	analog to digital
ADC	analog to digital converter
adj.	adjust, adjustment
ADV	advertising dimensional drawing
AHWT	anticipatory high water temperature
AISI	American Iron and Steel Institute
ALOP	anticipatory low oil pressure
alt.	alternator
Al	aluminum
ANSI	American National Standards Institute (formerly American Standards Association, ASA)
AO	anticipatory only
API	American Petroleum Institute
approx.	approximate, approximately
AR	as required, as requested
AS	as supplied, as stated, as suggested
ASE	American Society of Engineers
ASME	American Society of Mechanical Engineers
assy.	assembly
ASTM	American Society for Testing Materials
ATDC	after top dead center
ATS	automatic transfer switch
auto.	automatic
aux.	auxiliary
A/V	audio/visual
avg.	average
AVR	automatic voltage regulator
AWG	American Wire Gauge
AWM	appliance wiring material
bat.	battery
BBDC	before bottom dead center
BC	battery charger, battery charging
BCA	battery charging alternator
BCI	Battery Council International
BDC	before dead center
BHP	brake horsepower
blk.	black (paint color), block (engine)
blk. htr.	block heater
BMEP	brake mean effective pressure
bps	bits per second
br.	brass
BTDC	before top dead center
Btu	British thermal unit
Btu/min.	British thermal units per minute
C	Celsius, centigrade
cal.	calorie
CARB	California Air Resources Board
CB	circuit breaker
cc	cubic centimeter
CCA	cold cranking amps
ccw.	counterclockwise
CEC	Canadian Electrical Code
cfh	cubic feet per hour
cfm	cubic feet per minute
CG	center of gravity
CID	cubic inch displacement
CL	centerline
cm	centimeter
cmm	cubic meters per minute
CMOS	complementary metal oxide substrate (semiconductor)
cogen.	cogeneration
COM	communications (port)
conn.	connection
cont.	continued
CPVC	chlorinated polyvinyl chloride
crit.	critical
CRT	cathode ray tube
CSA	Canadian Standards Association
CT	current transformer
Cu	copper
cu. in.	cubic inch
cw.	clockwise
CWC	city water-cooled
cyl.	cylinder
D/A	digital to analog
DAC	digital to analog converter
dB	decibel
dBA	decibel (A weighted)
DC	direct current
DCR	direct current resistance
deg., °	degree
dept.	department
dia.	diameter
DI/EO	dual inlet/end outlet
DIN	Deutsches Institut fur Normung e. V. (also Deutsche Industrie Normenausschuss)
DIP	dual inline package
DPDT	double-pole, double-throw
DPST	double-pole, single-throw
DS	disconnect switch
DVR	digital voltage regulator
E, emer.	emergency (power source)
EDI	electronic data interchange
EFR	emergency frequency relay
e.g.	for example *(exempli gratia)*
EG	electronic governor
EGSA	Electrical Generating Systems Association
EIA	Electronic Industries Association
EI/EO	end inlet/end outlet
EMI	electromagnetic interference
emiss.	emission
eng.	engine
EPA	Environmental Protection Agency
EPS	emergency power system
ER	emergency relay
ES	engineering special, engineered special
ESD	electrostatic discharge
est.	estimated
E-Stop	emergency stop
etc.	et cetera (and so forth)
exh.	exhaust
ext.	external
F	Fahrenheit, female
fglass.	fiberglass
FHM	flat head machine (screw)
fl. oz.	fluid ounce
flex.	flexible
freq.	frequency
FS	full scale
ft.	foot, feet
ft. lbs.	foot pounds (torque)
ft./min.	feet per minute
g	gram
ga.	gauge (meters, wire size)
gal.	gallon
gen.	generator
genset	generator set
GFI	ground fault interrupter
gnd.	ground
gov.	governor
gph	gallons per hour
gpm	gallons per minute
gr.	grade, gross
gr. wt.	gross weight
H x W x D	height by width by depth
HC	hex cap
HCHT	high cylinder head temperature
HD	heavy duty
HET	high exhaust temperature
hex	hexagon
Hg	mercury (element)
HH	hex head
HHC	hex head cap
HP	horsepower
hr.	hour
HS	heat shrink
hsg.	housing
HVAC	heating, ventilation, and air conditioning
HWT	high water temperature
Hz	hertz (cycles per second)
IC	integrated circuit
ID	inside diameter, identification
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IMS	improved motor starting
in.	inch
in. H_2O	inches of water
in. Hg	inches of mercury
in. lbs.	inch pounds
Inc.	incorporated
ind.	industrial
int.	internal
int./ext.	internal/external
I/O	input/output
IP	iron pipe
ISO	International Organization for Standardization
J	joule
JIS	Japanese Industry Standard
k	kilo (1000)
K	kelvin
kA	kiloampere
KB	kilobyte (2^{10} bytes)
kg	kilogram

kg/cm^2	kilograms per square centimeter
kgm	kilogram-meter
kg/m^3	kilograms per cubic meter
kHz	kilohertz
kJ	kilojoule
km	kilometer
kOhm, kΩ	kilo-ohm
kPa	kilopascal
kph	kilometers per hour
kV	kilovolt
kVA	kilovolt ampere
kVAR	kilovolt ampere reactive
kW	kilowatt
kWh	kilowatt-hour
kWm	kilowatt mechanical
L	liter
LAN	local area network
L x W x H	length by width by height
lb.	pound
lbm/ft^3	pounds mass per cubic feet
LCB	line circuit breaker
LCD	liquid crystal display
ld. shd.	load shed
LED	light emitting diode
Lph	liters per hour
Lpm	liters per minute
LOP	low oil pressure
LP	liquefied petroleum
LPG	liquefied petroleum gas
LS	left side
L_{wa}	sound power level, A weighted
LWL	low water level
LWT	low water temperature
m	meter, milli (1/1000)
M	mega (10^6 when used with SI units), male
m^3	cubic meter
m^3/min.	cubic meters per minute
mA	milliampere
man.	manual
max.	maximum
MB	megabyte (2^{20} bytes)
MCM	one thousand circular mils
meggar	megohmmeter
MHz	megahertz
mi.	mile
mil	one one-thousandth of an inch
min.	minimum, minute
misc.	miscellaneous
MJ	megajoule
mJ	millijoule
mm	millimeter
mOhm, mΩ	milliohm
MOhm, MΩ	megohm
MOV	metal oxide varistor
MPa	megapascal
mpg	miles per gallon
mph	miles per hour
MS	military standard
m/sec.	meters per second
MTBF	mean time between failure
MTBO	mean time between overhauls
mtg.	mounting
MW	megawatt
mW	milliwatt
μF	microfarad
N, norm.	normal (power source)
NA	not available, not applicable
nat. gas	natural gas
NBS	National Bureau of Standards
NC	normally closed
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
Nm	newton meter
NO	normally open
no., nos.	number, numbers
NPS	National Pipe, Straight
NPSC	National Pipe, Straight-coupling
NPT	National Standard taper pipe thread per general use
NPTF	National Pipe, Taper-Fine
NR	not required, normal relay
ns	nanosecond
O/C	overcrank
OD	outside diameter
OEM	original equipment manufacturer
O/F	overfrequency
opt.	option, optional
O/S	oversize, overspeed
OSHA	Occupational Safety and Health Administration
O/V	overvoltage
oz.	ounce
p., pp.	page, pages
PA	packed accessory
PC	personal computer
PCB	printed circuit board
pF	picofarad
PF	power factor
ph.	phase
PHC	Phillips head crimptite (screw)
PHH	Phillips hex head (screw)
PHM	pan head machine (screw)
PLC	programmable logic control
PMG	permanent magnet generator
pot	potentiometer, potential
ppm	parts per million
PROM	programmable read only memory
psi	pounds per square inch
pt.	pint
PTC	positive temperature coefficient
PTO	power takeoff
PVC	polyvinyl chloride
qt.	quart
qty.	quantity
R	replacement (emergency) power source
rad.	radiator, radius
RAM	random access memory
RDO	relay driver output
ref.	reference
rem.	remote
RFI	radio frequency interference
RH	round head
RHM	round head machine (screw)
rly.	relay
rms	root mean square
rnd.	round
ROM	read only memory
rot.	rotate, rotating
rpm	revolutions per minute
RS	right side
RTV	room temperature vulcanization
SAE	Society of Automotive Engineers
scfm	standard cubic feet per minute
SCR	silicon controlled rectifier
s, sec.	second
SI	*Systeme international d'unites,* International System of Units
SI/EO	side in/end out
sil.	silencer
SN	serial number
SPDT	single-pole, double-throw
SPST	single-pole, single-throw
spec, specs	specification(s)
sq.	square
sq. cm	square centimeter
sq. in.	square inch
SS	stainless steel
std.	standard
stl.	steel
tach.	tachometer
TD	time delay
TDC	top dead center
TDEC	time delay engine cooldown
TDEN	time delay emergency to normal
TDES	time delay engine start
TDNE	time delay normal to emergency
TDOE	time delay off to emergency
TDON	time delay off to normal
temp.	temperature
term.	terminal
TIF	telephone influence factor
TIR	total indicator reading
tol.	tolerance
turbo.	turbocharger
typ.	typical (same in multiple locations)
U/F	underfrequency
UHF	ultrahigh frequency
UL	Underwriter's Laboratories, Inc.
UNC	unified coarse thread (was NC)
UNF	unified fine thread (was NF)
univ.	universal
U/S	undersize, underspeed
UV	ultraviolet
U/V	undervoltage
V	volt
VAC	volts alternating current
VAR	voltampere reactive
VDC	volts direct current
VFD	vacuum fluorescent display
VGA	video graphics adapter
VHF	very high frequency
W	watt
WCR	withstand and closing rating
w/	with
w/o	without
wt.	weight
xfmr	transformer

Appendix B Common Hardware Application Guidelines

Use the information below and on the following pages to identify proper fastening techniques when no specific reference for reassembly is made.

Bolt/Screw Length: When bolt/screw length is not given, use Figure 1 as a guide. As a general rule, a minimum length of one thread beyond the nut and a maximum length of 1/2 the bolt/screw diameter beyond the nut is the preferred method.

Washers and Nuts: Use split lock washers as a bolt locking device where specified. Use SAE flat washers with whiz nuts, spiralock nuts, or standard nuts and preloading (torque) of the bolt in all other applications.

See Appendix C, General Torque Specifications, and other torque specifications in the service literature.

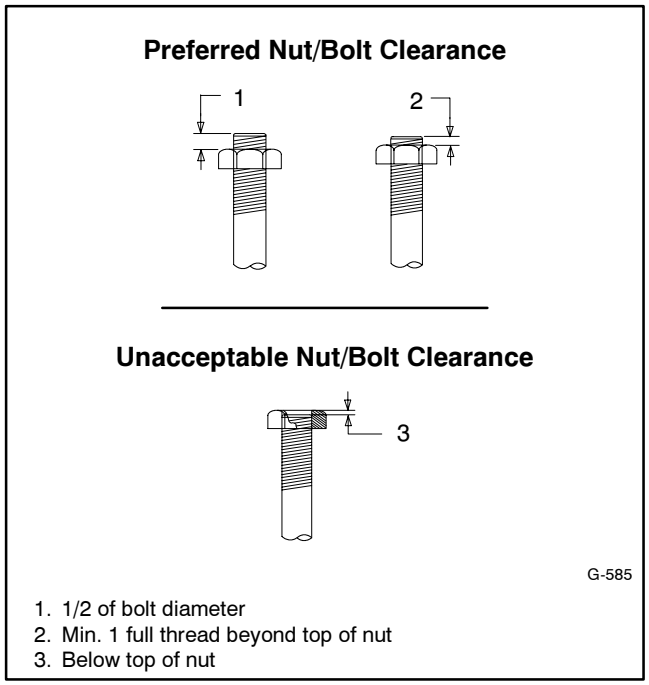


Figure 1 Acceptable Bolt Lengths

Steps for common hardware application:

1. Determine entry hole type: round or slotted.
2. Determine exit hole type: fixed female thread (weld nut), round, or slotted.

   For round and slotted exit holes, determine if hardware is greater than 1/2 inch in diameter, or 1/2 inch in diameter or less. Hardware that is *greater than 1/2 inch* in diameter takes a standard nut and SAE washer. Hardware *1/2 inch or less* in diameter can take a properly torqued whiz nut or spiralock nut. See Figure 2.
3. Follow these SAE washer rules after determining exit hole type:
   a. Always use a washer between hardware and a slot.
   b. Always use a washer under a nut (see 2 above for exception).
   c. Use a washer under a bolt when the female thread is fixed (weld nut).
4. Refer to Figure 2, which depicts the preceding hardware configuration possibilities.

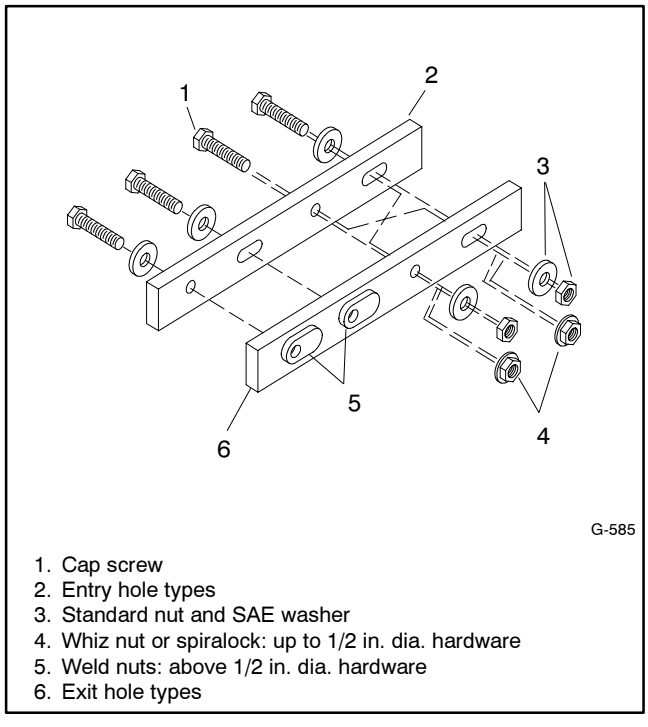


Figure 2 Acceptable Hardware Combinations

Appendix C General Torque Specifications

Use the following torque specifications when service literature instructions give no specific torque values. The charts list values for new plated, zinc phosphate, or oiled threads. Increase values by 15% for nonplated threads. All torque values are +0%/–10%.

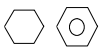
American Standard Fasteners Torque Specifications					
		Assembled into Cast Iron or Steel			Assembled into Aluminum
Size	Torque Measurement	Grade 2	Grade 5	Grade 8	Grade 2 or 5
8-32	Nm (in. lb.)	1.8 (16)	2.3 (20)	—	1.8 (16)
10-24	Nm (in. lb.)	2.9 (26)	3.6 (32)	—	2.9 (26)
10-32	Nm (in. lb.)	2.9 (26)	3.6 (32)	—	2.9 (26)
1/4-20	Nm (in. lb.)	6.8 (60)	10.8 (96)	14.9 (132)	6.8 (60)
1/4-28	Nm (in. lb.)	8.1 (72)	12.2 (108)	16.3 (144)	8.1 (72)
5/16-18	Nm (in. lb.)	13.6 (120)	21.7 (192)	29.8 (264)	13.6 (120)
5/16-24	Nm (in. lb.)	14.9 (132)	23.1 (204)	32.5 (288)	14.9 (132)
3/8-16	Nm (ft. lb.)	24.0 (18)	38.0 (28)	53.0 (39)	24.0 (18)
3/8-24	Nm (ft. lb.)	27.0 (20)	42.0 (31)	60.0 (44)	27.0 (20)
7/16-14	Nm (ft. lb.)	39.0 (29)	60.0 (44)	85.0 (63)	—
7/16-20	Nm (ft. lb.)	43.0 (32)	68.0 (50)	95.0 (70)	—
1/2-13	Nm (ft. lb.)	60.0 (44)	92.0 (68)	130.0 (96)	—
1/2-20	Nm (ft. lb.)	66.0 (49)	103.0 (76)	146.0 (108)	—
9/16-12	Nm (ft. lb.)	81.0 (60)	133.0 (98)	187.0 (138)	—
9/16-18	Nm (ft. lb.)	91.0 (67)	148.0 (109)	209.0 (154)	—
5/8-11	Nm (ft. lb.)	113.0 (83)	183.0 (135)	259.0 (191)	—
5/8-18	Nm (ft. lb.)	128.0 (94)	208.0 (153)	293.0 (216)	—
3/4-10	Nm (ft. lb.)	199.0 (147)	325.0 (240)	458.0 (338)	—
3/4-16	Nm (ft. lb.)	222.0 (164)	363.0 (268)	513.0 (378)	—
1-8	Nm (ft. lb.)	259.0 (191)	721.0 (532)	1109.0 (818)	—
1-12	Nm (ft. lb.)	283.0 (209)	789.0 (582)	1214.0 (895)	—

Metric Fasteners Torque Specifications, Measured in Nm (ft. lb.)				
	Assembled into Cast Iron or Steel			Assembled into Aluminum
Size (mm)	Grade 5.8	Grade 8.8	Grade 10.9	Grade 5.8 or 8.8
M6 x 1.00	5.6 (4)	9.9 (7)	14.0 (10)	5.6 (4)
M8 x 1.25	13.6 (10)	25.0 (18)	35.0 (26)	13.6 (10)
M8 x 1.00	21.0 (16)	25.0 (18)	35.0 (26)	21.0 (16)
M10 x 1.50	27.0 (20)	49.0 (35)	68.0 (50)	27.0 (20)
M10 x 1.25	39.0 (29)	49.0 (35)	68.0 (50)	39.0 (29)
M12 x 1.75	47.0 (35)	83.0 (61)	117.0 (86)	—
M12 x 1.50	65.0 (48)	88.0 (65)	125.0 (92)	—
M14 x 2.00	74.0 (55)	132.0 (97)	185.0 (136)	—
M14 x 1.50	100.0 (74)	140.0 (103)	192.0 (142)	—
M16 x 2.00	115.0 (85)	200.0 (148)	285.0 (210)	—
M16 x 1.50	141.0 (104)	210.0 (155)	295.0 (218)	—
M18 x 2.50	155.0 (114)	275.0 (203)	390.0 (288)	—
M18 x 1.50	196.0 (145)	305.0 (225)	425.0 (315)	—

Appendix D Common Hardware Identification

Screw/Bolts/Studs	
Head Styles	
Hex Head or Machine Head	
Hex Head or Machine Head with Washer	
Flat Head (FHM)	
Round Head (RHM)	
Pan Head	
Hex Socket Head Cap or Allen™ Head Cap	
Hex Socket Head or Allen™ Head Shoulder Bolt	
Sheet Metal Screw	
Stud	
Drive Styles	
Hex	
Hex and Slotted	
Phillips®	
Slotted	
Hex Socket	

Nuts	
Nut Styles	
Hex Head	
Lock or Elastic	
Square	
Cap or Acorn	
Wing	
Washers	
Washer Styles	
Plain	
Split Lock or Spring	
Spring or Wave	
External Tooth Lock	
Internal Tooth Lock	
Internal-External Tooth Lock	

Hardness Grades	
American Standard	
Grade 2	
Grade 5	
Grade 8	
Grade 8/9 (Hex Socket Head)	
Metric	
Number stamped on hardware; 5.8 shown	

Allen™ head screw is a trademark of Holo-Krome Co.

Phillips® screw is a registered trademark of Phillips Screw Company.

Sample Dimensions

American Standard (Screws, Bolts, Studs, and Nuts)

1/4-20 x 1

- 1 — Length In Inches (Screws and Bolts)
- 20 — Threads Per Inch
- 1/4 — Major Thread Diameter In Fractional Inches Or Screw Number Size

Metric (Screws, Bolts, Studs, and Nuts)

M8-1.25 x 20

- 20 — Length In Millimeters (Screws and Bolts)
- 1.25 — Distance Between Threads In Millimeters
- M8 — Major Thread Diameter In Millimeters

Plain Washers

9/32 x 5/8 x 1/16

- 1/16 — Thickness
- 5/8 — External Dimension
- 9/32 — Internal Dimension

Lock Washers

5/8

- 5/8 — Internal Dimension

Appendix E Common Hardware List

The Common Hardware List lists part numbers and dimensions for common hardware items.

American Standard

Part No.	Dimensions
Hex Head Bolts (Grade 5)	
X-465-17	1/4-20 x .38
X-465-6	1/4-20 x .50
X-465-2	1/4-20 x .62
X-465-16	1/4-20 x .75
X-465-18	1/4-20 x .88
X-465-7	1/4-20 x 1.00
X-465-8	1/4-20 x 1.25
X-465-9	1/4-20 x 1.50
X-465-10	1/4-20 x 1.75
X-465-11	1/4-20 x 2.00
X-465-12	1/4-20 x 2.25
X-465-14	1/4-20 x 2.75
X-465-21	1/4-20 x 5.00
X-465-25	1/4-28 x .38
X-465-20	1/4-28 x 1.00
X-125-33	5/16-18 x .50
X-125-23	5/16-18 x .62
X-125-3	5/16-18 x .75
X-125-31	5/16-18 x .88
X-125-5	5/16-18 x 1.00
X-125-24	5/16-18 x 1.25
X-125-34	5/16-18 x 1.50
X-125-25	5/16-18 x 1.75
X-125-26	5/16-18 x 2.00
230578	5/16-18 x 2.25
X-125-29	5/16-18 x 2.50
X-125-27	5/16-18 x 2.75
X-125-28	5/16-18 x 3.00
X-125-22	5/16-18 x 4.50
X-125-32	5/16-18 x 5.00
X-125-35	5/16-18 x 5.50
X-125-36	5/16-18 x 6.00
X-125-40	5/16-18 x 6.50
X-125-43	5/16-24 x 1.75
X-125-44	5/16-24 x 2.50
X-125-30	5/16-24 x .75
X-125-39	5/16-24 x 2.00
X-125-38	5/16-24 x 2.75
X-6238-2	3/8-16 x .62
X-6238-10	3/8-16 x .75
X-6238-3	3/8-16 x .88
X-6238-11	3/8-16 x 1.00
X-6238-4	3/8-16 x 1.25
X-6238-5	3/8-16 x 1.50
X-6238-1	3/8-16 x 1.75
X-6238-6	3/8-16 x 2.00
X-6238-17	3/8-16 x 2.25
X-6238-7	3/8-16 x 2.50
X-6238-8	3/8-16 x 2.75
X-6238-9	3/8-16 x 3.00
X-6238-19	3/8-16 x 3.25
X-6238-12	3/8-16 x 3.50
X-6238-20	3/8-16 x 3.75
X-6238-13	3/8-16 x 4.50
X-6238-18	3/8-16 x 5.50
X-6238-25	3/8-16 x 6.50

Part No.	Dimensions
Hex Head Bolts, cont.	
X-6238-14	3/8-24 x .75
X-6238-16	3/8-24 x 1.25
X-6238-21	3/8-24 x 4.00
X-6238-22	3/8-24 x 4.50
X-6024-5	7/16-14 x .75
X-6024-2	7/16-14 x 1.00
X-6024-8	7/16-14 x 1.25
X-6024-3	7/16-14 x 1.50
X-6024-4	7/16-14 x 2.00
X-6024-11	7/16-14 x 2.75
X-6024-12	7/16-14 x 6.50
X-129-15	1/2-13 x .75
X-129-17	1/2-13 x 1.00
X-129-18	1/2-13 x 1.25
X-129-19	1/2-13 x 1.50
X-129-20	1/2-13 x 1.75
X-129-21	1/2-13 x 2.00
X-129-22	1/2-13 x 2.25
X-129-23	1/2-13 x 2.50
X-129-24	1/2-13 x 2.75
X-129-25	1/2-13 x 3.00
X-129-27	1/2-13 x 3.50
X-129-29	1/2-13 x 4.00
X-129-30	1/2-13 x 4.50
X-463-9	1/2-13 x 5.50
X-129-44	1/2-13 x 6.00
X-129-51	1/2-20 x .75
X-129-45	1/2-20 x 1.25
X-129-52	1/2-20 x 1.50
X-6021-3	5/8-11 x 1.00
X-6021-4	5/8-11 x 1.25
X-6021-2	5/8-11 x 1.50
X-6021-1	5/8-11 x 1.75
273049	5/8-11 x 2.00
X-6021-5	5/8-11 x 2.25
X-6021-6	5/8-11 x 2.50
X-6021-7	5/8-11 x 2.75
X-6021-12	5/8-11 x 3.75
X-6021-11	5/8-11 x 4.50
X-6021-10	5/8-11 x 6.00
X-6021-9	5/8-18 x 2.50
X-6239-1	3/4-10 x 1.00
X-6239-8	3/4-10 x 1.25
X-6239-2	3/4-10 x 1.50
X-6239-3	3/4-10 x 2.00
X-6239-4	3/4-10 x 2.50
X-6239-5	3/4-10 x 3.00
X-6239-6	3/4-10 x 3.50
X-792-1	1-8 x 2.25
X-792-5	1-8 x 3.00
X-792-8	1-8 x 5.00

Part No.	Dimensions	Type
Hex Nuts		
X-6009-1	1-8	Standard
X-6210-3	6-32	Whiz
X-6210-4	8-32	Whiz
X-6210-5	10-24	Whiz
X-6210-1	10-32	Whiz
X-6210-2	1/4-20	Spiralock
X-6210-6	1/4-28	Spiralock
X-6210-7	5/16-18	Spiralock
X-6210-8	5/16-24	Spiralock
X-6210-9	3/8-16	Spiralock
X-6210-10	3/8-24	Spiralock
X-6210-11	7/16-14	Spiralock
X-6210-12	1/2-13	Spiralock
X-6210-15	7/16-20	Spiralock
X-6210-14		Spiralock
X-85-3	5/8-11	Standard
X-88-12	3/4-10	Standard
X-89-2	1/2-20	Standard

Washers

Part No.	ID	OD	Thick.	Bolt/ Screw
X-25-46	.125	.250	.022	#4
X-25-9	.156	.375	.049	#6
X-25-48	.188	.438	.049	#8
X-25-36	.219	.500	.049	#10
X-25-40	.281	.625	.065	1/4
X-25-85	.344	.687	.065	5/16
X-25-37	.406	.812	.065	3/8
X-25-34	.469	.922	.065	7/16
X-25-26	.531	1.062	.095	1/2
X-25-15	.656	1.312	.095	5/8
X-25-29	.812	1.469	.134	3/4
X-25-127	1.062	2.000	.134	1

Metric

Hex head bolts are hardness grade 8.8 unless noted.

Part No.	Dimensions
Hex Head Bolts (partial thread)	
M931-06040-60	M6-1.00 x 40
M931-06055-60	M6-1.00 x 55
M931-06060-60	M6-1.00 x 60
M931-06070-60	M6-1.00 x 70
M931-06075-60	M6-1.00 x 75
M931-06090-60	M6-1.00 x 90
M931-08035-60	M8-1.25 x 35
M931-08040-60	M8-1.25 x 40
M931-08040-82	M8-1.25 x 40*
M931-08045-60	M8-1.25 x 45
M931-08050-60	M8-1.25 x 50
M931-08055-82	M8-1.25 x 55*
M931-08060-60	M8-1.25 x 60
M931-08070-60	M8-1.25 x 70
M931-08070-82	M8-1.25 x 70*
M931-08075-60	M8-1.25 x 75
M931-08080-60	M8-1.25 x 80
M931-08090-60	M8-1.25 x 90
M931-08095-60	M8-1.25 x 95
M931-08100-60	M8-1.25 x 100
M931-10040-60	M10-1.50 x 40
M931-10045-60	M10-1.50 x 45
M931-10050-60	M10-1.50 x 50
M931-10055-60	M10-1.50 x 55
M931-10060-60	M10-1.50 x 60
M931-10065-60	M10-1.50 x 65
M931-10070-60	M10-1.50 x 70
M931-10080-60	M10-1.50 x 80
M931-10090-60	M10-1.50 x 90
M931-10100-60	M10-1.50 x 100
M931-12045-60	M12-1.75 x 45
M931-12050-60	M12-1.75 x 50
M931-12055-60	M12-1.75 x 55
M931-12060-60	M12-1.75 x 60
M931-12065-60	M12-1.75 x 65
M931-12080-60	M12-1.75 x 80
M931-12090-60	M12-1.75 x 90
M931-12100-60	M12-1.75 x 100
M931-12110-60	M12-1.75 x 110
M931-16090-60	M16-2.00 x 90
M931-20065-60	M20-2.50 x 65
M931-20120-60	M20-2.50 x 120
M931-20160-60	M20-2.50 x 160
M931-22090-60	M22-2.50 x 90
M931-22120-60	M22-2.50 x 120
M931-22160-60	M22-2.50 x 160
M931-24090-60	M24-3.00 x 90
M931-24120-60	M24-3.00 x 120
M931-24160-60	M24-3.00 x 160

Part No.	Dimensions
Hex Head Bolts (full thread)	
M933-04006-60	M4-0.70 x 6
M933-05050-60	M5-0.80 x 50
M933-06010-60	M6-1.00 x 10
M933-06014-60	M6-1.00 x 14
M933-06016-60	M6-1.00 x 16
M933-06020-60	M6-1.00 x 20
M933-06025-60	M6-1.00 x 25
M933-06040-60	M6-1.00 x 40
M933-06050-60	M6-1.00 x 50
M933-08016-60	M8-1.25 x 16
M933-08020-60	M8-1.25 x 20
M933-08025-60	M8-1.25 x 25
M933-08030-60	M8-1.25 x 30
M933-10012-60	M10-1.50 x 12
M961-10020-60	M10-1.25 x 20
M933-10020-60	M10-1.50 x 20
M933-10025-60	M10-1.50 x 25
M933-10030-60	M10-1.50 x 30
M933-10030-82	M10-1.50 x 30*
M961-10035-60	M10-1.25 x 35
M933-10035-60	M10-1.50 x 35
M933-12016-60	M12-1.75 x 16
M933-12020-60	M12-1.75 x 20
M933-12025-60	M12-1.75 x 25
M933-12025-82	M12-1.75 x 25*
M933-12030-60	M12-1.75 x 30
M933-12040-60	M12-1.75 x 40
M933-12040-82	M12-1.75 x 40*
M961-14025-60	M14-1.50 x 25
M933-14025-60	M14-2.00 x 25
M961-16025-60	M16-1.50 x 25
M933-16025-60	M16-2.00 x 25
M933-16030-82	M16-2.00 x 30*
M933-16035-60	M16-2.00 x 35
M933-16040-60	M16-2.00 x 40
M933-16050-60	M16-2.00 x 50
M933-16050-82	M16-2.00 x 50*
M933-16060-60	M16-2.00 x 60
M933-18050-60	M18-2.50 x 50
M933-18060-60	M18-2.50 x 60
Pan Head Machine Screws	
M7985A-03010-20	M3-0.50 x 10
M7985A-03012-20	M3-0.50 x 12
M7985A-04020-20	M4-0.70 x 20
M7985A-05010-20	M5-0.80 x 10
M7985A-05012-20	M5-0.80 x 12
Flat Head Machine Screws	
M965A-05016-20	M5-0.80 x 16

Part No.	Dimensions	Type
Hex Nuts		
M934-03-50	M3-0.50	Standard
M934-04-50	M4-0.70	Standard
M934-05-50	M5-0.80	Standard
M982-05-80	M5-0.80	Elastic Stop
M6923-06-80	M6-1.00	Spiralock
M934-06-64	M6-1.00	Std. (green)
M982-06-80	M6-1.00	Elastic Stop
M6923-08-80	M8-1.25	Spiralock
M934-08-60	M8-1.25	Standard
M982-08-80	M8-1.25	Elastic Stop
M6923-10-80	M10-1.50	Spiralock
M982-10-80	M10-1.50	Elastic Stop
M6923-12-80	M12-1.75	Spiralock
M982-12-80	M12-1.75	Elastic Stop
M982-14-80	M14-2.00	Elastic Stop
M6923-16-80	M16-2.00	Spiralock
M982-16-80	M16-2.00	Elastic Stop
M982-18-80	M18-2.50	Elastic Stop
M934-20-80	M20-2.50	Standard
M982-20-80	M20-2.50	Elastic Stop
M934-22-80	M22-2.50	Standard
M982-22-80	M22-2.50	Elastic Stop
M934-24-80	M24-3.00	Standard
M982-24-80	M24-3.00	Elastic Stop

Washers

Part No.	ID	OD	Thick.	Bolt/ Screw
M125A-03-80	3.2	7.0	0.5	M3
M125A-04-80	4.3	9.0	0.8	M4
M125A-05-80	5.3	10.0	1.0	M5
M125A-06-80	6.4	12.0	1.6	M6
M125A-08-80	8.4	16.0	1.6	M8
M125A-10-80	10.5	20.0	2.0	M10
M125A-12-80	13.0	24.0	2.5	M12
M125A-14-80	15.0	28.0	2.5	M14
M125A-16-80	17.0	30.0	3.0	M16
M125A-18-80	19.0	34.0	3.0	M18
M125A-20-80	21.0	37.0	3.0	M20
M125A-24-80	25.0	44.0	4.0	M24

* This metric hex bolt's hardness is grade 10.9.

Appendix F Operating Hour Service Log

Use the log below to keep a cumulative record of operating hours on your generator set and the dates required services were performed. Enter hours to the nearest quarter hour.

	OPERATING HOURS		SERVICE RECORD	
DATE RUN	HOURS RUN	TOTAL HOURS	SERVICE DATE	SERVICE

KOHLER®
POWER SYSTEMS

KOHLER CO. Kohler, Wisconsin 53044
Phone 920-565-3381, Web site www.kohlergenerators.com
Fax 920-459-1646 (U.S.A. Sales), Fax 920-459-1614 (International)
For the nearest sales and service outlet in U.S.A. and Canada
Phone 1-800-544-2444

Kohler® Power Systems
Asia Pacific Headquarters
7 Jurong Pier Road
Singapore 619159
Phone (65)264-6422, Fax (65)264-6455

TP-5737 5/01b

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